D. Public Utilities

As previously mentioned, the IID will not provide all of its electric power requirements from its own sources. It is presently connected to other electric power networks for some of its power needs and, if desirable, should be able to obtain a portion of its future power requirements from the existing regional grid (although there are limitations on long-term availability of this resource). Sewer service will not be necessary for the project facilities. The desalination plant (if constructed) would be connected to a septic tank system to handle small-scale domestic sewage. Telephone service will be provided from Pacific Bell.

The need for public utility service is considered an insignificant adverse impact.

E. Public Health and Safety

The danger that people and animals may fall into the lined water canals will pose a problem to public health and safety. Where appropriate, providing escape structures for people and animals in the canals would greatly reduce this danger, thereby making it an insignificant adverse impact.

4.1.8 CULTURAL AND PALEONTOLOGICAL RESOURCES

A. Cultural Resources

All adverse effects on cultural resource sites are cumulative and irreversible. Whether the cause is direct (i.e., by construction activities that may disturb, disperse, bury, or otherwise affect prehistoric or historical remains) or by indirect activities (i.e., increased traffic or erosion), the unavoidable result is the loss of information these sites may contain. Even controlled scientific excavation undertaken as a mitigating measure is regarded as a diminution of the total data base, although some positive effect may be realized through the investigation of sites about which very little is known at present.

Although all sites may be important to some degree or they may have a special value to the Native American community, areas that may be found to have the greatest research potential are the relict lake shorelines, desert pavement, and localities of early historic activities relating to settlement, mining, agriculture and irrigation, or transportation corridors.

B. Paleontological Resources

Paleontological resources in the study area will be subject to both the direct and indirect adverse impacts that accompany construction. The most significant effects will be from direct impacts, those that disturb the resource and result in the loss of fossils and important scientific data. These impacts arise primarily from grading and excavation and end with construction.

However, covering exposures with concrete facing or water is permanent and prevents future study of the rock. Indirect impacts are those that do not greatly disturb rock but still result in the loss of fossils and associated data. The most important indirect impact is the unauthorized collection of fossils by project personnel during construction.

The importance of potential adverse impacts to a particular formation (or the sensitivity of that formation to impacts) is considered to be on the same level as that of the known or potential resources that the unit contains in the study area. For example, impacts to a highly important formation are considered highly important. Impacts to the continental deposits near Pilot Knob are considered to be highly important. Impacts to the lake deposits, alluvium, and dune sand are considered to be of low importance.

4.1.9 VISUAL RESOURCES

Impacts to visual resources from the proposed water conservation program will be minimal. The proposed modifications are consistent with the existing conditions. No change in the VRM classification of the visual resources of the study area will occur as the result of implementation of the proposed project.

The desalination plant and facilities would (if constructed) constitute a major visual intrusion; however, the visual impact will be limited to the immediate vicinity of the structures and will not be significant.

4.1.10 AIR QUALITY, CLIMATOLOGY, AND NOISE

A. Air Quality and Climatology

The impacts to air quality are associated primarily with construction activities. Fugitive dust emissions would result from construction activities associated with possible major projects such as canal lining, reservoir construction, and construction of the desalination plant. These emissions may exceed the local 24-hour TSP standards during the short-term construction period.

Other emissions that could result from this project would be NO_x, SO_2, and CO from construction equipment, as well as operational emissions from diesel-powered tailwater pumps and operation of the desalination plant. Only the operational impacts would require use of best available control technology (BACT).

Changes in the Salton Sea's surface area may have a slight impact on local climatology by reducing humidity levels and by generating somewhat greater air temperature variations on land areas left by the retreating shoreline. Some increases in fugitive dust from formerly submerged lands may occur; however, these impacts are not expected to be significant.

B. Noise

The impact of project-generated noise is based on a disruption of speech and sleep, an increase in annoyance, and a perception of change in ambient noise levels. The accepted standards for residential areas are long-term Ldn of 55 dBA (EPA, 1974) to 65 dBA (HUD, 1979). The HUD standards are used here because they are more compatible with those presently used by other federal and state agencies.

Studies have shown that, in addition to the compliance with the above standards, noise impact has to be assessed also in terms of the perceived change in ambient sound levels. A change of 5 dBA is considered noticeable, whereas a 10-dBA change is equivalent to changing from a suburban to an urban environment. For the present study, an increase of 5 dBA over the existing ambient level has been considered to be significant.

1. Construction Impacts. The noise effects from a project's construction activity are a function of the noise generated by construction equipment, the location and sensitivity of nearby land uses, and the timing and duration of the noise-generating activities. There would be no major construction activity associated with installing the improved flow-monitoring structures, nonleak gates, system automation, and miscellaneous measures. As such, the increase in the noise level from the above activities would be minimal and insignificant.

Analyses indicate that the overall construction noise level (Ldn) would be between 54 and 58 dBA at 1,000 ft, between 48 and 52 dBA at 2,000 ft, and between 42 and 46 dBA at 3,000 ft. Thus, the short-term increase in noise level (Ldn) due to the construction activity would be less than 5 dBA for a receptor located in an urbanized area (existing ambient noise level about 50 dBA) at a distance greater than 2,000 ft, as well as for a receptor located in an open agricultural, desert, or wildlife management area (existing ambient noise level about 45 dBA) at a distance greater than 3,000 ft. The short-term increase would, thus, be noticeable but would not be disturbing to the community, particularly because no construction activity would take place at night.

2. Operational Impact. Noise-generating activities from project operations would be mainly from the desalination plant (if constructed). The operation of the equipment would be continuous for 24 hours, and the maximum relative increase in noise levels would occur during the nighttime. The noise from the operation of pumps, motors, and other equipment would be discernible in the areas close to the desalination plant, and the increase in noise level over the existing value may be significant. However, at distances greater than 5,000 ft, the impact would not be significant.

4.2 NO-PROGRAM ALTERNATIVE

The no-program alternative, discussed in subsection 2.4, would result in a phasing out of existing conservation programs, except for O&M and training expenditures to ensure the continued conservation of 138,000 AF/year. No new construction project would generate any direct physical impact to the environment. This compares with the physical disturbances associated with canal lining, reservoir and desalination plant construction, and other activities associated with the proposed water conservation program. The existing environmental conditions in Imperial Valley in most cases would be maintained essentially unchanged from those described in Chapter 3.

The Salton Sea would experience a significant beneficial impact by maintaining elevations generally close to the present-day elevation. The baseline no-conservation scenarios for the years 1986 to 2010 are shown in Appendix E (Tables E.5-4 and E.5-6). This data indicates that the sea level is essentially stable; the slight 0.6-ft decrease in elevation is a result of projected decreases in surface flows from Mexico. The no-project alternative would also maintain a slower rate of increase in Salton Sea salinity (see comparison in Table 4-1). However, the no-project alternative would still maintain a steady increase in salinity because of continued salt loading. This reduction in the rate of increase, however, is a significant beneficial effect.

The maintenance of the Salton Sea's elevation and a slower rate of increase in salinity would have the beneficial effects of extending the viability of the Salton Sea's fishery and associated supported communities (e.g., wildlife) for 3 to 4 more years. This would benefit fish and wildlife, but it would also benefit the recreational use of the Salton Sea and its vicinity. The positive economic effects associated with this activity (e.g., fishing, hunting, bird-watching) would be maintained for 3 to 4 more years. However, the IID would experience a severe penalty, based on a recent settlement with John Elmore, of approximately $693,000 more than the penalty due if the expanded water conservation program were implemented. In addition, the IID may have to pay penalties to other landowners.

Without an expanded water conservation program, there will not be enough water to meet projected demand for the year 2010. The current demand within the IID's service area is 2.77 million AF/year. This demand is projected to increase to 3.00 million AF/year by the year 2010. In addition, there is a projected demand of 510,000 AF/year by the higher priority users within the Seven-Party Agreement. Finally, the Coachella Valley Water District (CVWD) currently uses about 420,000 AF/year. With no allowance for increased demand by the CVWD, the total projected demand is 3.93 million AF/year. Because there is only 3.85 AF/year of available water under the Seven-Party Agreement, there will be a shortfall of 80,000 AF/year. And because the IID's priority is higher than the CVWD's, this shortage will most likely occur in the CVWD's service area and represents about a 20% decrease in the amount of agricultural land that would be irrigated by the CVWD.

Because the IID has a higher priority than does the CVWD, Coachella could receive less water after the year 2000 than it does now. Without implementation of further conservation programs, there would be no program-induced increases in Colorado River salinity. This would be a beneficial effect prior to construction and operation of the desalination plant. Without this plant, however, the farmers would experience continued increases in salinity. Soils would thus have a continued salt buildup or would require more water for leaching.

The no-program alternative will not meet the District's goals as stated in Chapter 2.

4.3 INITIAL TRANSFER

The transfer of 100,000 AF/year of conserved water is viewed as a first step in implementing the expanded water conservation program because it will generate funds needed to pay for all water conservation projects and measures.

The transfer of conserved water to a water agency outside the District using the Colorado River Aqueduct is without direct environmental effects because it does not change the flow in the river. It is expected that this initial transfer would not have a significant effect on flows in the Colorado River between Parker Dam and Imperial Dam. Water previously conserved by IID is presently not ordered and therefore is not delivered by the USBR to Imperial Dam. The transfer agreement would allow southern California's water agencies to divert water from Lake Havasu, thus removing this water from storage, or from being diverted below Parker Dam as excess flow. The transferred water could be a combination of stored water and excess flow. In any given year, the source of this water would depend on the quantity of water in storage and annual runoff. However, long-term projections on the Colorado River show demand exceeding supply. Therefore in future years, water conserved by the IID but not transferred would not be diverted to Imperial Dam. This water would be used by other users. However, the initial transfer can be viewed as a commitment to implement an expanded conservation program with the program's consequential environmental effects. These environmental effects can, therefore, be considered as indirect or secondary impacts of the initial transfer.

4.4 NO-INITIAL-TRANSFER ALTERNATIVE

The initial transfer of 100,000 AF/year of conserved water could take place regardless of any additional conservation effort that is or is not implemented. If there is no transfer, there will be insufficient funds for implementing the expanded water conservation program, unless funds are obtained from other sources. In addition, there is no advantage, from an environmental viewpoint, of not transferring the water. The water would remain as surplus, and it would be available for use by the holders of water rights junior to the IID's. Therefore, this alternative is not acceptable because it does not meet the District's goals as given in Chapter 2.

4.5 CUMULATIVE IMPACTS

The California State Clearinghouse computer was searched in March 1986 for notices filed in accordance with CEQA for the period 1984 through 1986 (to date) to identify projects that could generate cumulative impacts in association with the IID's expanded Water Conservation Program. Projects in Imperial County and eastern Riverside County were included in the review.

Twenty-two projects were identified. There were four projects for residential and/or commercial developments, three for recreational vehicle parks, seven utility expansion projects, five industrial developments, two geothermal projects, and one freeway interchange modification.

The largest residential/commercial development was the Bravo Farms annexation by the City of Calexico. This proposal has been pursued for about 10 years and is currently inactive. It is proposed to cover 680 acres and include 3,898 dwellings, apartments, and mobile home spaces, plus two commercial centers, one government center, and a park and school area. In a similar category, a 3,000-space recreational vehicle park is proposed for "slab city." It will include waste and water treatment plants and other support facilities. The developer has asked that the IID furnish water.

Two significant utility projects were also identified, both sponsored by the IID. The IID's Power Department proposes to construct a 230-kV electrical transmission line from the new Southern California Edison Mirage substation to the proposed IID Coachella Valley substation. The IID also has proposed to construct a 92-kV transmission line from Glamis to a proposed open pit gold mine at Mesquite.

Activities in the East Mesa KGRA are also of interest. For example, the Ormesa Geothermal Binary Powerplant is a 30-MW (gross) geothermal powerplant for which a negative declaration has been submitted by Region 7 of the CRWQCB. Other exploratory and developmental projects are proposed for the East Mesa KGRA.

All of these active projects are within the framework established by local plans and policies that were considered when projections of water demand were formulated (Parsons, 1985). No significant cumulative impacts at a program or regional level other than those identified as deriving from the expanded water conservation plan have been identified.

Any projects of significant scope with the potential to create localized cumulative impacts will be included in each Focused EIR prepared for the IID's Water Conservation Program. The projects listed and discussed above include all that were identified for this Program EIR and Focused EIR for the initial transfer of 100,000 AF/year of conserved water.

CHAPTER 5
MITIGATION MEASURES

CHAPTER 5

MITIGATION MEASURES

The mitigation measures that the District will incorporate into the proposed expanded conservation program are presented in Table 4-1. These measures are in addition to the mitigation measures initially incorporated into the program that consist of development of a groundwater reserve and a desalination plant (if that is the salinity control measure implemented). The environmental effects of the program's mitigation measures must be addressed in an EIR. In essentially all cases, the mitigation measures that have been addressed are environmentally beneficial. The only exception is the proposed desalination plant. Although this facility is proposed to offset the increase in irrigation water salinity caused by the program and the other anticipated salinity increases in the Colorado River, it will have notable environmental effects. The reject brine stream must be disposed of. Either of the two disposal options - discharge to the Alamo River or discharge to percolation/evaporation ponds - can have adverse impacts. These are discussed in Chapter 4 and Table 4-1. Energy requirements for reverse osmosis desalination plants are significant, and certain sludges from water pretreatment are sometimes classed as hazardous. For these reasons, other methods of salinity control or mitigation will be evaluated in search of less costly and more environmentally acceptable alternatives. These would be discussed in a project-specific EIR before implementation of this program element would occur.

Although the IID is committed to the implementation of its expanded water conservation program using sound environmental procedures, there are significant adverse environmental impacts that the District cannot solve alone. These impacts fall into two general categories:

(1) <u>Salton Sea</u>

Although committed to the search for a feasible way to save the Salton Sea, any study initiated by the District will require the support of all concerned governmental agencies. Without a solution being implemented, the decline of the sea will continue with or without implementing an expanded water conservation program. The Salton Sea's fishery and other associated recreational uses would be eliminated at an accelerated rate.

(2) New and Alamo River

The discharges from agricultural, domestic, and industrial sources, in particular those from Mexico, will become increasingly damaging to the New and Alamo Rivers as the District's conservation program reduces drain flows and their dilution effects. The loss of habitat and biota will be mitigated to an acceptable level by the District, but other potential beneficial uses will be diminished. In addition, the uptake of pollutants by aquatic biota and wetland vegetation would increase, and more pollutants would enter the food chains of the New and Alamo Rivers.

The greatest public concern, other than the ensured availability of water for all uses within Imperial County, appears to be over the fate of the Salton Sea and the environmental and economic costs relating to the loss of this fishery. The District has neither the authority nor the resources to assume responsibility for the Salton Sea. However, the District believes that there is a real possibility, through joint efforts with other agencies, that all or a major part of the Salton Sea can be stabilized at an elevation and salinity that would preserve the fishery.To this end, the District is willing to participate in a study to determine ways that the competing demands on the Salton Sea may be balanced and managed to maximize the benefits. This study would be coordinated with other ongoing efforts and would focus on legal, environmental, institutional, fiscal, and technical issues.

The loss of the Salton Sea's fishery may be delayed to some extent if (1) a fish hatchery were established and operated, and (2) if the Salton Sea's fishery were managed as a put-and-take fishery. These measures would counteract the reduced fish reproduction caused by high salinity. The normal lead agency for implementing this mitigating measure is the California Department of Fish and Game. The District is willing to include an analysis of feasibility discussed above for this type of hatchery in the Salton Sea Study. Although this is a temporary solution, it may be useful until a more permanent solution is found.

The decreased flows and higher salinities expected in the New and Alamo Rivers could only be mitigated by diverting substantial quantities of irrigation or drain water to these rivers. This is not practical. The habitat loss and degradation will be mitigated by enhancing other habitats or by creating new ones. This will require using some portion of drain or other water for habitat maintenance. The problem is to assign responsibility for the management of the habitat.

Increased pollutant uptake by the food chain is another consequence of reduced flows. The principal concern is with the New River, which carries a large amount of pollutants from Mexico. Not all of these pollutants have been identified, much less quantified. This problem has been recognized; however, the solution has been evasive because of funding problems, unresolved international issues, and questions of priority. The District is willing to participate in a comprehensive water quality analysis of the New and Alamo Rivers with funds received in the initial transfer of water so there will be a better understanding of the nature of the pollution in order to assess the public health risks. With this better understanding, an appropriate solution can be developed. If this pollution problem is ultimately solved, the impacts from pollutant uptake would be greatly mitigated. The foregoing discussion concentrates on mitigating measures that can be implemented in coordination with other agencies and organizations using funds received from the initial transfer of water.

In summary, the District is fully aware of the environmental issues integral to the expanded water conservation program. The IID's Board is ready to devote a portion of the initial revenue received from transfer payments to fund mitigation measures and studies aimed at finding long-term solutions to problems such as the death of the Salton Sea.

CHAPTER 6
GROWTH-INDUCING IMPACTS

CHAPTER 6

GROWTH-INDUCING IMPACTS

The expanded water conservation program proposed by the IID would not hinder, enhance, or facilitate growth within Imperial County in ways inconsistent with local plans and policies. There is now sufficient water for all needs, and ample provision for future needs has been incorporated into basic projections of water demands for the year 2010 (Parsons, 1985a). These demands are summarized below in Table 6-1.

Table 6-1 - Water Demands (AF/year)

Demand Type	Current Baseline	Year 2010 Demand Baseline	Year 2010 Demand Maximum Possible
Agricultural	2,245,000	2,381,000	2,597,000
Municipal	36,600	56,500	81,300
Industrial (incl. geothermal)	16,800	90,000	266,100
Transmission losses	458,600	458,600	505,300
Other	10,400	15,000	17,500
Total	2,767,400	3,001,100	3,467,200
Total (rounded)	2,770,000	3,000,000	3,500,000
Demand reduction by conservation	-	-358,000	-358,000
Net demand	2,770,000	2,642,000	3,142,000

Source: Parsons, 1985a.

An increase in the availability of water to others outside of the IID's service area, which may in part be used to offset losses caused by increased diversions by Arizona, may occur in two ways:

(1) Through the formal transfer of up to 250,000 AF/year of conserved water.

(2) Because additional amounts of conserved water that have not been transferred are available for diversion as surplus water from the Colorado River.

If water is conserved by the IID, then less water is ordered by the IID for release from Parker Dam for delivery to Imperial Dam and diversion to the All-American Canal. Therefore, more water would be available for diversion through the California River Aqueduct at Parker Dam or, if not needed, the water could be stored at Parker Dam or at upstream reservoirs or discharged as excess. There are treaty obligations to share surpluses with Mexico; therefore, if excess water is released at Parker Dam, the flow would pass through Imperial Dam into Mexico. The advantage of a formal transfer of up to 250,000 AF/year for the receiving water agencies is that a guaranteed increase in supply is obtained, rather than depending on surplus water.

It is the responsibility of the other water agencies receiving transferred or surplus water to meet the water demands of the users they serve. The overall water demands are a consequence of land use decisions made by general purpose governments (cities and counties) having police power over the use of land within their boundaries. These land use decisions are governed by the general plans these agencies must adopt under state law. Furthermore, when changes, amendments, or new general plans are adopted, they are subject to review under the CEQA, and either Negative Declarations or EIRs must be adopted. Therefore, the collective environmental impacts of future growth to be served by southern California's water agencies have already been addressed in accordance with state law.

CHAPTER 7

SHORT-TERM BENEFICIAL USES VS. LONG-TERM ENVIRONMENTAL IMPACTS

CHAPTER 7

SHORT-TERM BENEFICIAL USES VS. LONG-TERM ENVIRONMENTAL EFFECTS

Short-term beneficial uses are minimal because the overall objectives and the design of the expanded water conservation program are for the long-term beneficial use of the environment. Immediate benefits would be limited to improvements in the District's fiscal condition.

Two principal impacts are cumulative, long-term adverse environmental effects of the proposed expanded water conservation program:

(1) Salton Sea

Although committed to the search for a feasible way to save the Salton Sea, any study initiated by the District will require the support of concerned governmental agencies. Without a solution being implemented, the decline of the sea will continue with or without implementing an expanded water conservation program. The Salton Sea's fishery and other associated recreational uses would be eliminated at an accelerated rate.

(2) New and Alamo River

The discharges from agricultural, domestic, and industrial sources, in particular those from Mexico, will become increasingly damaging to the New and Alamo Rivers when the District's conservation program reduces drain flows and their dilution effects. The loss of habitat and biota will be mitigated to an acceptable level by the District, but other potential beneficial uses will be diminished. In addition, the uptake of pollutants by aquatic biota and wetland vegetation would increase, and more pollutants would enter the food chains of the New and Alamo Rivers. This could be a long-term health risk of limited extent if bioaccumulation occurs in fish and wildlife used for human consumption.

The proposed program should be implemented in the time frame proposed in order to meet the programs objectives of conserving water and conferring maximum benefits to the District and its landowner beneficiaries. Delaying the program could result in:

(1) Probable increase in water rates.

(2) Potential loss of water rights for water not beneficially used or conserved.

(3) Delay in finding solutions to the problems of the Salton Sea.

(4) Less water available to the District for the development of new agricultural lands, geothermal development, and other uses.

CHAPTER 8

IRREVERSIBLE IMPACTS

CHAPTER 8

IRREVERSIBLE ENVIRONMENTAL CHANGES

The overall effect of the proposed expanded water conservation program is to strengthen the District's commitment to and investment in a modern, efficient irrigation system dedicated to serving all water demands within its boundaries. With or without the implementation of an expanded water conservation program, significant irreversible changes may occur to the Salton Sea if efforts to find and implement an approach to saving the beneficial uses of the sea are not successful. The use of nonrenewable resources will be limited largely to materials and petroleum-based fuels required for the construction of facilities. Petroleum fuels or coal may be consumed to provide up to 60 MW of power needed to operate the facilities and offset the loss of hydropower caused by reduced flows in the All-American Canal.

CHAPTER 9
CONTRIBUTORS

CHAPTER 9

CONTRIBUTORS

This EIR was prepared by, and under the direction of, the Imperial Irrigation District, Imperial, California. The individuals directly involved in the report's preparation, and their organization affiliations (IID - Imperial Irrigation District; PWRI - Parsons Water Resources, Inc.; RMPCo - The Ralph M. Parsons Company; and ES - Engineering-Science, Inc.), are listed in Table 9-1.

Table 9-1 - IID EIR Contributors

Program Activity	Contributor (affiliation)
Lead Agency Direction, and EIR Coordination and Review	Charles L. Shreves (IID), General Manager
	Donald Twogood (IID), Executive Officer
	Lonnie McGlocklin (IID), Assistant to the General Manager
	Robert Wilson (IID), Manager, Water Department
	Douglas Welch (IID), Conservation Supervisor
EIR Coordinator	Phillip J. Morris (ES)
Project Description	Charles L. Shreves (IID) Robert Wilson (IID) George C. Wheeler (IID) Bueford L. Bradley (IID) Douglas Welch (IID) Melvyn R. Brown (PWRI) Dwight B. Hunt (PWRI) Richard Palmer (PWRI) John Engel (ES)

Table 9-1 (Contd)

Program Activity	Contributor (affiliation)
Technical Staff	
Agronomy	Douglas Welch (IID) Robert Adam (ES) Richard Palmer (PWRI) Richard E. Burke
Air Quality	Alireza Rabizadeh, D. Env. (ES)
Biology	Louis B. McNairy Bruce Snyder, Ph.D. (ES) Laura Simonek (ES)
Civil Engineering	Jesse Silva (IID) Robert Lang (IID) Jerome Stetson (PWRI) Richard Ramirez (PWRI) John Engel (ES)
Cultural Resources	Roberta Greenwood (ES)
Economics	Thomas Corrigan (RMPCo)
Geology and Seismicity	Richard Makdisi (ES)
Hydrology and Water Resources	John Engel (ES) Philip N. Storrs (ES)
Infrastructure	Thomas Corrigan (RMPCo)
Land Use	Laura Simonek (ES)
Noise	Richard E. Burke Krishna Nand, Ph.D. (ES)
Paleontology	E. Bruce Lander, Ph.D. (ES)
Soils	Douglas Welch (IID) Robert Adam (ES)
Visual Resources	Laura Simonek (ES)
Water Quality	Paul Amberg (ES) John Engel (ES) Alireza Rabizadeh, D. Env. (ES)
Word Processor	Patricia J. Hamp (PWRI)
Managing Editor	Judith Herman (PWRI)

CHAPTER 10

CONTACTS/PUBLIC PARTICIPATION

CHAPTER 10

CONTACTS/PUBLIC PARTICIPATION

In order to thoroughly assess the issues involved with water conservation and transfer, the IID staff and its consultants met with and/or requested information from the following organizations and individuals:

10.1 FEDERAL

(1) Army Corps of Engineers
(2) Bureau of Land Management
(3) Bureau of Reclamation
(4) Department of Agriculture - Soil Conservation Service
(5) Fish and Wildlife Service
(6) Naval Air Facility (El Centro)
(7) Torres-Martinez Indian Reservation

10.2 STATE

(1) Air Resources Board
(2) Colorado River Board
(3) Department of Fish and Game
(4) Department of Parks and Recreation
(5) Department of Transportation
(6) Department of Water Resources
(7) Employment Development Department
(8) Office of Planning and Research
(9) Regional Water Resources Control Board

10.3 COUNTY OF IMPERIAL

(1) Agricultural Commissioner
(2) Assessor's Office
(3) Division of Community Economic Development
(4) Planning Commission
(5) Planning Department

10.4 COUNTY OF RIVERSIDE

(1) Assessor's Office
(2) Planning Department

10.5 MUNICIPAL

(1) City of Brawley
(2) City of Calexico
(3) City of Calipatria
(4) City of El Centro
(5) City of Holtville
(6) City of Imperial
(7) City of Westmorland

10.6 OTHERS

(1) Mr. Ben Abatti, Jr.
(2) Mr. Ron Ackert
(3) Ben Holt Company
(4) Mr. Lester Bornt
(5) Calexico Chamber of Commerce.
(6) California Institute of Technology
(7) California Women in Agricultural
(8) Centennial Energy, Inc.
(9) Chevron Geothermal Company of California
(10) Mr. Carroll O. Childers
(11) Coachella Valley Water District
(12) El Centro Chamber of Commerce
(13) Mr. John Elmore
(14) Farm Bureau
(15) Mr. John Hawk
(16) Mr. Cliff Hurley
(17) Imperial Country Board of Supervisors
(18) Imperial Energy Corporation
(19) Imperial Valley College Museum
(20) Imperial Valley Vegetable Growers Association
(21) Kennecott
(22) Law Offices of D. Dwight Worden
(23) Mr. Brad Luckey
(24) Magma Power Company
(25) Mr. Jack McConnell
(26) Mr. Rick Mealey
(27) Metropolitan Water District
(28) Nyland Chamber of Commerce
(29) Mr. Don Obergfell
(30) Ormat Systems, Inc.
(31) Palo Verde Irrigation District
(32) Mr. Rod Pittman
(33) Private Industry Council
(34) Redwine and Sherrill
(35) Regional Economic Development, Inc.
(36) Salton Sea Coordinating Council
(37) San Diego County Water Authority
(38) Mr. Steve Scaroni
(39) Soil Conservation Service (USDA - see Federal)
(40) South Valley Power Corporation
(41) Southern California Association of Governments
(42) Southern California Edison Company

(43) Union Geothermal Division
(44) University of California, Los Angeles
(45) University of California, Riverside
(46) Valley Independent Bank
(47) Mr. Tom Waggoner
(48) Wells Fargo Bank
(49) The Western Power Group, Inc.
(50) The Wildlife Society
(51) Yuma Audubon Society

10.7 PUBLIC PARTICIPATION

In addition to the above contacts, a public meeting was held on February 5, 1986, at the District's offices in El Centro, California, for the purpose of providing and receiving information on the preparation of the EIR. Public comments and concerns were received, and the information was considered in the preparation of the EIR.

It is the District's intention that an additional public meeting will be held during the DEIR review period. The purpose of this meeting will be to provide and receive information concerning the DEIR.

APPENDIXES

APPENDIX A
ACRONYMS AND ABBREVIATIONS

ac	acre
ACEC	area of critical environmental concern
AF	acre-foot
AF/year	acre-foot per year
amsl	above mean sea level
BACT	best available control technology
B-E	Bookman-Edmonston Engineering, Inc.
BLM	Bureau of Land Management
BOD	biochemical oxygen demand
CAA	Clean Air Act
CARB	California Air Resources Board
CDCA	California Desert Conservation Area
CDFG	California Department of Fish and Game
CDMG	California Division of Mines and Geology
CDPR	California Department of Parks and Recreation
CDWR	California Department of Water Resources
CEQ	Council on Environmental Quality
CEQA	California Environmental Quality Act
CIMIS	California Irrigation Management Information System
CNEL	community noise equivalent level
CO	carbon monoxide
CO_2	carbon dioxide
COD	chemical oxygen demand
COE	U.S. Army Corps of Engineers
CRWQCB	California Regional Water Quality Control Board
CSRI	Cultural Systems Research, Inc.
CU	consumptive use
CVWD	Coachella Valley Water District
dBA	decibel, A-weighted
District	Imperial Irrigation District
EC	electroconductivity
EDA	Economic Development Administration
EIR	Environmental Impact Report (state)
EP	effective precipitation (ft)
EPA	Environmental Protection Agency
ES	Engineering-Science, Inc.
ET	evapotranspiration (ft)
°C	degree Celsius
°F	degree Fahrenheit
ft	foot
ft/mile	foot per mile
ft^3	cubic foot
ft^3/sec	cubic foot per second
FWS	U.S. Fish and Wildlife Service
gpcd	gallon per capita per day

gpd/ft	gallon per day per foot
gpm	gallon per minute
g	gram
GWRS	groundwater reserve system
ha	hectare
HCD	Department of Housing and Community Development, State of California
hp	horsepower
HUD	U.S. Department of Housing and Urban Development
ICAPCD	Imperial County Air Pollution Control District
IID	Imperial Irrigation District (the District)
in.	inch
IVCM	Imperial Valley College Museum, El Centro
KCWA	Kern County Water Agency
kg	kilogram
KGRA	known geothermal resource area
kV	kilovolt
kW	kilowatt
kWh	kilowatt-hour
L	liter
LACM	Los Angeles County Museum of Natural History
Ldn	day-night sound level
LR	leach requirement
LW	leach water
meq	milliequivalent
MGD	million gallons per day
μg/L	microgram per liter
mmho/cm	millimho per centimeter (electroconductivity)
mg/L	milligram per liter
mi^2	square mile
mL	milliliter
μm	micrometer
MPN	most probable number
mpy	mile per year
ms.	manuscript
msl	mean sea level
MW	megawatt
MWD	Metropolitan Water District of Southern California
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NSR	New Source Review
NWR	National Wildlife Refuge
O&M	operations and maintenance
od	outside diameter
ORV	offroad vehicle
Parsons	Parsons Water Resources, Inc.
pH	negative logarithm of the hydrogen ion concentration
PIC	Private Industry Council of Imperial County, Inc.
PM_{10}	particulate matter smaller then 10 micrometers
ppb	part per billion
ppm	part per million

ppt	part per thousand
PSD	prevention of significant deterioration
psi	pound per square inch
psia	pound per square inch absolute
psig	pound per square inch gauge
REDI	Regional Economic Development, Inc.
ROC	reactive organic compounds
ROW	right-of-way
RR	railroad
SCAG	Southern California Association of Governments
SCS	U.S. Soil Conservation Service
SDCWA	San Diego County Water Authority
SEDAB	Southeast Desert Air Basin
SO_2	sulfur dioxide
SWP	California State Water Project
SWRCB	State Water Resources Control Board
T	tier
TDS	total dissolved solids
TSP	total suspended particulates
TSS	total suspended solids
UCMP	University of California, Museum of Paleontology, Berkeley
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USGS	U.S. Geological Survey
VRM	visual resource management
wt	weight
yd	yard
yd^3	cubic yard

APPENDIX B
GLOSSARY

Absorption	The process by which a substance is taken into and included within another substance, i.e., the intake of water by soil or the intake of gases, water, nutrients, or other substances by plants.
Acre-foot	A quantity of water sufficient to cover 1 acre to a depth of 1 ft, i.e., 43,560 ft^3 or 325,851 gallons.
Adsorption	The increased concentration of molecules or ions at a surface, including exchangeable cations and anions on soil particles.
Aggradation	The process of deposition of sediments contained in flowing water as velocity is reduced. Deltas and floodplains are caused by aggradation.
Alluvial fan	A geologic formation created by sediment deposition of a stream where it issues from mountainous terrain to a floodplain or bottomland.
Alluvium	Water-deposited materials such as sand, silt, or clay.
Angler-day	The equivalent of one person engaged in fishing activities for the duration of a single day.
Annual (ephemeral) plant	Plant that completes life cycle and dies in 1 year or less (Range Term Glossary Committee, 1974).
Anoxic	Void of oxygen.
Applied water	Water delivered to an agricultural user. Also called "delivered water." It does not include precipitation or distribution system losses.
Aquifer	A water-bearing stratum of permeable rock, sand, or gravel.

Arroyo	A small steep-sided and usually dry watercourse with a flat floor.
Assemblage	The total inventory of cultural material from a single archaeological site or from a spatially, chronologically, or culturally distinctive part of a complex site.
Available water-holding capacity	The quantity of water held in the soil after free drainage has occurred (expressed in inches per unit depth).
A-weighting	A weighting scheme applied to sound level measurements; corresponds approximately to human hearing sensitivity. Expressed as decibels, A-weighted (dBA).
Bajada	Broad alluvial slope extending from the base of a mountain range out into a basin and formed by coalescence of separate alluvial fans.
Bedrock	Solid rock underlying unconsolidated surface materials.
Benthic	Of, relating to, or occurring at the bottom of a body of water.
Biome (biotic communities)	A major ecological community that is characterized by a distinctive vegetation, physiognomy, or appearance.
Caliche	Gravel, sand, or desert debris cemented by porous calcium carbonate.
Canal cutout	The act of blocking all flow to a canal or lateral.
Carnivorous	Meat eating.
Community noise equivalent level	Similar to day-night sound level but with 5 dBA added to the average noise level between 7 p.m. to 10 p.m. and 10 dBA added to the average noise level between 10 p.m. to 7 a.m.
Consumptive use	Water used by plants in transpiration and growth, including water vapor from adjacent soil surfaces or from intercepted precipitation in a specified time (inches per day, feet per year).

Consumptive use of applied water	Consumptive use less the water supplied by precipitation.
Conveyance system efficiency	The ratio of the volume of water delivered to users to the volume of water introduced into the conveyance system.
Crop coefficient	A coefficient that relates the evapotranspiration of a given crop at a specific time in its growth stage to a reference evapotranspiration condition. This coefficient incorporates the effects of crop growth stage, crop density, and other cultural factors affecting evapotranspiration.
Cropping pattern	The acreage distribution of different crops in any period, usually 1 year in a given area such as a county, water agency, or farm.
Crop rotation	The practice of growing different crops in succession on the same land chiefly to preserve the productive capacity of the soil and increase farm revenues.
Crop water requirement	Crop consumptive use plus the water required to provide the leaching requirement.
Day-night sound level	The equivalent sound level over a 24-hour period with a 10-dB penalty added to the average noise level between the nighttime hours of 10 p.m. to 7 a.m. in order to account for the increased sensitivity of people to noise during that period.
Decibel	A unit for expressing the ratio of two amounts of sound power; equal to 10 times the logarithm of this ratio.
Deep percolation	The movement of water by gravity downward through the soil profile beyond the crop root zone.
Demand scheduling	Delivery of water to the user by a water agency whenever the user demands it, subject to the rules and regulations of the operating agency.
Desert pavement	A pavementlike surface of small stones or pebbles on a flat desert area.

Detritus	Decayed and decaying plant and animal matter.
District irrigation efficiency	The ratio of the volume of water consumptively used in the District to the volume of water delivered to the District's conveyance system at Drop No. 1.
Division	A group of the IID's personnel responsible for water deliveries, operation, and maintenance of the irrigation system within a certain geographic area within the District.
Drop No. 1	The initial drop structure located on the All-American Canal; considered as the head of the IID conveyance system.
Double cropping	The practice of harvesting two or more crops on the same parcel of land during a 12-month period.
Ekman dredge	A type of bottom-sampling dredge that scoops up bottom material from water bodies for analysis.
Electrical conductivity	Ability of water to transmit electric current, the reciprocal of resistivity, expressed as millimho per centimeter (mmho/cm).
Emergent macrophytes	Large aquatic plants that are rooted in water but grow above the waterline.
Endangered plant species	Species of plants in danger of extinction throughout all or a significant portion of their ranges. Existence may be endangered because of the destruction, drastic change, or severe curtailment of habitat or because of overexploitation, disease, predation, or unknown reasons. Plant taxa from very limited areas (e.g., the type localities only or from restricted fragile habitats) are usually considered endangered.
Endemic	Existing naturally in the environment.
Environment	The surrounding conditions, influences, or forces that affect or modify an organism or an ecological community and ultimately determine its form and survival.

Environmental Impact Report (EIR)	A California state decisionmaking report equivalent to the federal EIS and required by the California Environmental Quality Act (CEQA).
Environmental Impact Statement (EIS)	An analytical document developed for use by decisionmakers to weigh the environmental consequences of a potential decision. An EIS is a federal document required by the National Environmental Policy Act (NEPA).
Ephemeral stream	A stream that flows only during and after rainfall.
Epiphytic	Plants that grow on other plants but are not parasitic.
Eutrophic	Describing a shallow water body with abundant organic matter and reduced levels of dissolved oxygen.
Evapotranspiration (ET)	Water transpired and evaporated from plants and surrounding soil surfaces, expressed in feet per year (ft/year).
Fallow land	Land normally used for crop production but left unsown for one or more growing seasons.
Farm head ditch	A water conveyance channel located at the head of each field that is owned, operated, and maintained by the farmer.
Fingerlings	Juvenile forms of fishes.
Fishery	A collection of fishes that are of sport or commercial value.
Food web	Food and feeding interrelationship between plants and animals.
Forage fish	A fish that is eaten by other fish or other animals.
Geoglyph	See Intaglio.
Graben	A block of the earth's crust generally with a length much greater than its width that has dropped relative to the blocks on either side.

Growing season	The timer period between killing frosts used for crop production.
Habitat	(1) A specific set of physical conditions that surrounds a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space. (2) The natural home or dwelling place of an organism.
Herbivorous	Plant eating.
Holocene	Recent geologic time; refers to approximately the last 11,000 years.
Hydrographer	A District employee serving as a water tender who is responsible for control of water within a main canal and at turnouts to minor canals and laterals.
Hydrophilic	Preferring moist places or water as a habitat.
Infiltration rate	The rate of percolation of water through the soil profile; typically expressed as inches of water per hour.
Intaglio	A design or pattern made by removing stones from the desert floor. Also, Geoglyph.
Invertebrates	Animals without backbones.
Irrecoverable water	That portion of delivered water degraded through beneficial use to a level that makes it uneconomical to reclaim or reuse.
Isotherm	A band or belt of equivalent temperature.
Lacustrine	Lake-type environments with slower moving waters.
Lacustrine basin	A low area formed at the bottom of a lake from material deposited in lake water and exposed when the water level was lowered.
Leach water	Water applied to flush excess salts from the root zone.

Leaching requirement	The quantity of water necessary for the removal of salts contained in the root zone.
Lithic scatter	Surface distribution (close or dispersed) of stone artifacts and/or the raw material byproducts of manufacturing stone tools.
Lysimeter	A device such as a tank or large barrel containing a mass of soil, usually planted with vegetation, that is isolated hydrologically from its surroundings. The device is commonly used in research to determine the evapotranspiration rate of various crops in a controlled environment.
Macroinvertebrate	Animals without backbones that are large enough to be seen with the naked eye.
Mean sea level	The arithmetic mean of all sea levels at all tides.
National Pollutant Discharge Elimination System (NPDES)	The information prescribed by, and submitted on, the National Pollutant Discharge Elimination System Application for Permit to Discharge for applying for issuance of a discharge permit to the Administrator of the Environmental Protection Agency.
Omnivorous	Meat and plant eating.
On-farm irrigation efficiency	The ratio of the volume of water used for consumptive use and leaching requirements to the volume of water delivered to a farm (applied water).
On-farm system	The method used to distribute and apply water to the fields; included are gravity/surface systems, pressurized systems such as sprinklers and drop lines, and tailwater disposal or recovery systems.
Percolation	A qualitative term applying to the downward movement of water through soil, especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of one or less.
Perennial plant	A plant that has a life cycle of 3 years or more.

Perennial stream	A stream that flows throughout the year.
Periphytic	Animals or plants that adhere to submerged plants.
Permeability	The rate at which water moves through a wetted soil, expressed in inches per hour (in./hr).
Petroglyph	A design or pattern incised into a rock surface; may be in horizontal or vertical position.
pH	A measure of acidity; equal to the negative logarithm of the hydrogen ion concentration.
Phreatophyte	A deep-rooted plant that obtains its water from the water table or the layer of soil just above it.
Pictograph	A design or pattern painted onto a rock surface.
Piscivorous	Fish eating.
Phytoplankton	Free-floating plants, usually one-celled or composed of few cells.
Pleistocene	Epoch covering early part of Quaternary Period, i.e., 10,000 to about 2 million years ago.
Precipitation	The total measurable supply of water of all forms of falling moisture, including dew, rain, mist, snow, hail, and sleet; usually expressed as depth of water on a horizontal surface on a daily, monthly, or yearly basis.
Present perfected rights	Water rights acquired in accordance with state law, which right has been exercised by the actual diversion of a specific quantity of water that has been applied to a defined area of land.
Primary producers	Lowest level of the food chain; plants that produce their own food.
Pump-back system	A return flow system in which tailwater is pumped back to the head of an irrigation ditch for reuse.

Quaternary	Period covering approximately last 2 million years of earth history; includes Pleistocene and Holocene epochs.
Recreation-day	The equivalent of one person engaged in recreational activities for the duration of a single day.
Return flow	The portion of water diverted for irrigation that returns to groundwater or stream system for potential rediversion or in-stream uses.
Return flow system	A system that recycles runoff water either by pumping it back to the supply or by using it sequentially on a lower field. (Often a reservoir is required to enable flexible operation and to save labor.)
Reused water	Water used beneficially more than once.
Rhizome	A rootlike stem of a plant.
Riparian	Pertaining to the bank or shore of a water body.
Riverine	Riverlike environments with relatively fast-moving waters.
Root zone	The layer of soil (varying in depth from a few inches for grasses to as much as 10 ft for alfalfa) where the majority of crop roots extract water (normal depth of irrigation is about 6 ft).
Rotation scheduling	Delivery of water to the user by a water agency usually on the basis of fixed amounts of water at fixed intervals.
Ruderal	Vegetation that grows in response to human disturbances, e.g., along roadsides, field boarders, or railroad ROWs.
Rundown water	Water left in a lateral after all scheduled deliveries have been made.
Runoff	Water that leaves an area or field as surface flow.

Salinity	Total amount of dissolved solids in water in parts per million by weight when all carbonate is converted to oxide, bromide and iodide to chloride, and all organic matter is oxidized. Roughly equivalent to milligrams per liter.
Seepage	Downward or lateral movement of water from a reservoir canal or pipe through a pervious or semipervious bottom.
Significant	As applied in archaeological evaluations, denotes that a site is intact and has the potential to yield important scientific information; evaluated at the federal level by eligibility to the National Register of Historic Places, and evaluated at the state level under the definitions of CEQA, as amended.
Sodic	Refers to soils with high sodium concentrations.
Soluble	Capable of being dissolved in a fluid.
Specific yield	The volume of water that an unconfined aquifer releases from storage per unit surface area of aquifer per unit decline in the water table, i.e., expressed in percentage.
Storage coefficient	The volume of water that is released from or is taken into storage per unit surface area of an aquifer per unit change in the component of head normal to that surface, i.e., dimensionless.
Structure (soil)	The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates.
Submergent macrophytes	Large aquatic plants that grow entirely under water.
Substrates	Solid materials to which organisms are attached or upon which they live.
Tailwater	Surface water runoff occurring at the end of an irrigated field when water that had been applied exceeds the soil's infiltration rates.
Taxa	Taxonomic groups of any rank or size.

Texture (soil)	Relative proportion of sand, silt, and clay particles in a particular type of soil.
Threatened animal species	Any animal species likely to become endangered within the foreseeable future throughout all or a significant part of its range.
Threatened plant species	Any species likely to become endangered within the foreseeable future throughout all or a significant portion of its range, including species categorized as rare, very rare, or depleted.
Time of advance	The duration of time required for water to flow from the upper to the lower end of a field.
Time (duration) of irrigation (opportunity time)	The length of time that water should be applied to replace water consumptively used and provide for leaching.
Tolerance limits	Maximum or minimum criteria required to support life.
Total dissolved solids	The total dry weight of solids dissolved in a liquid per unit volume, e.g., mg/L.
Transmissivity	A measure of the flow through a vertical strip of aquifer one unit wide. Computed as the average permeability times the saturated thickness.
Transpiration	The physiological process in which plant tissues give off water vapor to the atmosphere.
Trophic dynamics	The interrelationship between different levels in the food chain depicting the passage of energy between trophic levels.
Trophic level	A nourishment level in a food chain in which organisms obtain their food in the same number of steps or in the same general manner. Plant producers constitute the lowest level, followed by herbivores and a series of carnivores at the higher levels.

Unaccountable water	The difference between the quantity of water introduced into the system and the quantity delivered; usually expressed as a percentage of delivered water. Many local factors affect this percentage from system to system.
Unit water use	The average quantity of water used per person, acre, etc., over a specified period of time.
Vegetation type	A plant community with specific distinguishable characteristics described by the dominant vegetation present.
Water conservation	Planned management to prevent or reduce loss or waste of water in order to enhance beneficial uses.
Watermaster	The IID employee responsible for control of water in the All-American Canal and allocation of water to the Divisions of the IID.
Wetlands	Periodically, seasonally, or continuously submerged landscapes populated by species and/or life forms differing from adjacent communities.
Wheel row	A furrow that is tracked on by farm machinery.
Zanjero	An IID employee responsible for control of water within a "run" of laterals and/or minor canals and at farm turnouts within his run or area of responsibility; also called the water tender or ditchrider.
Zooplankton	Free-floating aquatic animals, usually one-celled or composed of few cells.

APPENDIX C
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APPENDIX D
CULTURAL/PALEONTOLOGICAL RESOURCES
INVENTORY OF THE IID

CONTENTS

APPENDIX D

CULTURAL/PALEONTOLOGICAL RESOURCES INVENTORY OF THE IID

The Imperial Irrigation District (IID) has proposed to upgrade its system by lining existing canals with concrete or, where necessary, by excavating new canals parallel to existing ones. Numerous reservoirs would also be constructed at sites to be determined. The area under consideration includes the East Highline Canal, Vail and Rositas Supply Canals, numerous lateral canals, and that part of the All-American Canal between the Coachella Canal at Drop No. 1 and Pilot Knob Check. Construction for this project could adversely affect cultural and paleontologic resources by ground-disturbing impacts that could result in the loss of resources and scientific data or by covering resources, which would make them inaccessible for future study. This report presents the results of cultural and paleontologic resource inventories for the areas of concern within the IID.

D.1 CULTURAL RESOURCES

D.1.1 METHODOLOGY

To derive the preliminary indications of the distribution and relative size of previously recorded sites within the IID's study area, the U.S. Geological Survey (USGS) quadrangle maps depicting the alignments of the East Highline and All-American Canals were compared with the archival masters maintained at the Imperial Valley College Museum, El Centro, which is the official repository and clearinghouse for cultural resource data in Imperial County. The data base is current for Indian sites but not historical sites, and the base maps do not delineate areas that have been surveyed. Museum staff archaeologists (Jay von Werlhof, Sherilee von Werlhof, and Ray Wilcox) were consulted, and they provided additional information about site types and sensitive localities, reliability of prior survey strategies, current research directions, county requirements, and potential federal input.

The literature reviewed included several prehistoric and historic overviews that, although prepared for areas outside of this undertaking, are relevant in terms of the cultural history and comparable environments (Wilke, 1978; USDI/BLM, 1979; Schaefer, 1981; CSRI, 1982). One report that specifically addresses a portion of the IID project was that prepared by von Werlhof and von Werlhof (1979a) describing Pilot Knob, East Mesa, and the eastern end of the All-American Canal. Most of the areas that have been systematically investigated lie either west of Calexico and El Centro or north of the All-American Canal, and all of the areas lie outside of the IID project site. Other sources were checked to determine what sites have been listed on the National Register of Historic Places (NRHP), determined eligible for the register, are deemed potentially eligible, or designated as state (CDPR, 1981) or county (Little, 1982) landmarks. These sites are discussed below.

A windshield survey was accomplished by driving the entire length of the access road beside the East Highline Canal, as well as selected access roads that provided views of the terrain crossed by the All-American Canal, with particular concern for the area surrounding Pilot Knob.

D.1.2 AFFECTED ENVIRONMENT

The study area encompasses several different environments that favored utilization and adaptations by successive cultures. On both sides of the All-American Canal from Pilot Knob westerly for at least 1 mile past Sidewinder Road are expanses of desert pavement that provided an abundance of lithic raw material for the manufacture of stone tools and that still reveal evidence of prehistoric activities. There are literally hundreds of geoglyphs (surface or horizontal rock art), petroglyphs, cleared circles, rock rings, and old trail systems. Many, but not all, of the geoglyphs have been mapped and accepted as a district on the NRHP. From Ogilby Road west, the All-American Canal flows through the southern edge of East Mesa, one of the most uniform topographic areas in Imperial County and, until recent investigations prompted by its status as a known geothermal resource area (KGRA), one of the least well known archaeologically (von Werlhof and von Werlhof, 1979b). Vegetation is profuse in sand and sandhill areas where the hummocks entrap moisture; creosote and mesquite are the dominant plants. Although surveys have been few and limited, numerous sites have been recorded near the dunes. These include temporary camps, interpreted as seasonal occupations of riverine tribes coming periodically to exploit the resources of Lake Cahuilla (von Werlhof and von Werlhof, 1979a). Old trails are visible intermittently across the weak terraces and through the shifting sands.

The East Highline Canal closely parallels sea level for most of its length, just west of the ancient beach. From the canal east to an elevation of 42-45 ft above mean sea level (amsl) is a corridor of potentially high site density. For example, 41 archaeological sites have already been recorded within 1,000 ft of the centerline along the approximately 8.5-mile alignment of the canal shown on the USGS Holtville East 7.5-minute quadrangle. This is not regarded as a total inventory (S. von Werlhof, personal communication, 1986); however, most sites are recorded along the east side of the canal where surveys have been concentrated. Presumably, there is a potential for sites occurring west of the canal where they would be less apparent because of cultivation. The other quadrangles intersected by the East Highline Canal are less well known at present, but they present comparable environmental conditions.

The Vail and Rositas Supply Canals, although not checked for resources, have a similar potential for containing resources similar to the East Highline Canal.

The historical utilization of the study area has been encouraged by the presence of mineral resources, particularly between the Cargo Muchacho Mountains and Picacho Wash, where known mines are north of the All-American Canal; by the need to develop transportation corridors; and by the growth of agriculture, which prompted development of the older water systems that preceded the modern canal network. The old plank road is a county-designated landmark and California Registered Historical Landmark No. 845 (Little, 1982); remnants may still be present on the south side of the All-American Canal, east of Drop No. 1. The first delivery of water into the Imperial Valley by the California Development Corporation in 1901 has been commemorated by a monument at the corner of Anza and Barbara Worth Roads, east of Calexico. Routes and facilities such as the old wooden headgates in use prior their to replacement by the All-American Canal in 1942 are also recognized as historical landmarks. Areas used by General Patton to train troops for desert combat in World War II are still being identified; districts in Riverside County have been nominated to the NRHP.

Survey coverage along the All-American Canal is not only limited, but investigations relating to power transmission lines have concentrated on the south side, particularly on the Midway Well and Midway Well NW USGS 7.5-minute quadrangles. Each has about 10 sites, and all are on the south side of the canal. This distribution is a function of the survey objectives and is not a result of diverse environmental factors. Historical sites are probably underrepresented in the entire study area because many of the older surveys did not identify, record, or evaluate anything but Indian sites. Coverage is also biased along the East Highline Canal, in part because agriculture is more intensive on the west side. However, in contrast to lands adjacent to the All-American Canal where a common environment on both sides suggests a uniform site distribution, the presence of the ancient beach line, which is usually an area of high site densities, presupposes that the highest site density will be on the east side of the East Highline Canal. Historical sites, unrecorded to date because they are in unsurveyed areas or because surveyors in years past were uninformed or unconcerned about these resources, may be present at wells or watering places, nodes in transportation networks (e.g., the historic town of Iris, mining localities, labor camps, pioneer trails and campsites, forts and waystations), and other places within the

IID where human activities have left evidence above or below the ground. Such sites may occur in areas to be disturbed.

An analysis of site patterning in comparable areas west of Calexico concluded that relative elevation above mean sea level is one of the most effective determinants of both site density and site type. Schaefer (1981) divided terrain in the La Rosita 230-kV interconnection corridor into the following three zones (percentages indicate portion of the total for each type of site within that particular zone):

(1) Below 40 ft amsl: Submerged until after A.D. 1450 and the final recession of Lake Cahuilla. Periodic exposures may have occurred during fluctuations in the water level. This zone contains the highest percentages of temporary camps (38.5%) and ceramic scatters (38.5%).

(2) From 40 ft to 50 ft amsl: Relic shoreline of Lake Cahuilla in the Holocene Epoch. High occurrences of lithic scatters (47.0%), temporary camps (23.5%), and lithic workshop areas (23.5%).

(3) Above 50 ft amsl: Habitable throughout the late Pleistocene and Holocene Epochs; major washes supplied seasonal water sources. Highest proportion of lithic scatters (64.0%). Lithic workshop areas represented by 20.0% of sites; lowest frequency of temporary camps at 16.0% (Schaefer, 1981).

Overall density was found to vary according to elevation, although the averages were moot because of high standard deviations and a complex, but limited, sampling strategy. In a more detailed survey of part of the same area, later investigators located 9 archaeological sites and 14 isolated archaeological occurrences in a 100-ft-wide, 5-mile-long corridor (Greenwood and Foster, 1983).

D.2 PALEONTOLOGICAL RESOURCES

D.2.1 METHODOLOGY

A records search was conducted at the Natural History Museum of Los Angeles County (LACM), Los Angeles, to establish an inventory of fossil localities in the IID. The museum also contains the locality records for the University of California Museum of Paleontology (UCMP), Berkeley. Geologic and paleontological literature of the area was reviewed, and paleontologists with knowledge of the area were also consulted for additional information regarding the paleontologic resources of the IID. Locality data for fossil sites was compared with geologic maps of the region to determine the formations that produced the remains. Geologic mapping of the study area was then examined to determine the distribution of the fossil-bearing units along the existing canal that have the potential for producing additional similar remains. A preconstruction field survey was conducted to locate exposures of potentially fossiliferous bedrock that might be adversely impacted by construction. The results of the data search and field survey are presented below.

D.2.2 AFFECTED ENVIRONMENT

The study area consists of Quaternary sediments deposited in and adjacent to prehistoric Lake Cahuilla, as well as Holocene alluvium and dune sand (Jennings, 1967; Strand, 1962). The East Highline Canal and the Vail and Rositas Supply Canals pass through Quaternary lake deposits. These deposits are exposed along the east side of the East Highline Canal, although they have been quarried locally for gravel. However, the area west of the canal is under heavy cultivation, and no exposure remains. Between the Coachella Canal and the Sand Hills to the east, the All-American Canal passes through Quaternary (Holocene) alluvium. In the Sand Hills, it passes through exposures of Quaternary (Holocene) dune sand and, near Pilot Knob, exposures of Quaternary (Pleistocene) nonmarine sediments. Most or all of the lateral canals and proposed reservoir sites are probably in areas of Quaternary lake deposits. Presumably, Pleistocene sediments occur in the canals or the shallow subsurface in all of the areas covered by Holocene alluvium and dune sand, as well as Quaternary lake deposits.

No fossil locality was documented along the canals during the data search or field survey. However, six Pleistocene continental vertebrate localities (IVCM 283; LACM 1654, 1719, 1726; UCMP V-5303, V-5931) have been identified in the region by Jefferson (in press). Except for LACM 1719, these localities, which occur in the lake deposits and possibly the nonmarine sediments, have produced remains belonging to extinct species of ground sloth, horse, camel, and bison. The material from IVCM 238 (Miller, 1985) and presumably UCMP V-5303 was discovered during excavation of the Coachella Canal. Lander (1985) has documented seven Pleistocene vertebrate localities from the nonmarine deposits along the Arizona side of the Colorado River near Blythe. LACM 1719 does not occur in strata that are exposed along the canals in the study area. Miller (1985) reports reworked fossil remains from the dune sand in the Sand Hills. Based on these records, the potential exists for additional specimens occurring along the canals and at potential reservoir sites in the lake deposits, nonmarine deposits, and the dune sand, particularly in the subsurface.

APPENDIX E
SALT BALANCE AND SALTON SEA ANALYSIS

CONTENTS

FIGURES

CONTENTS (Contd)

FIGURES (Contd)

TABLES

APPENDIX E

SALT BALANCE AND SALTON SEA ANALYSIS

CHAPTER E.1

INTRODUCTION

The water balance for the IID and the Salton Sea has been analyzed in detail (Parsons, 1985a). This appendix analyzes the salt balance for the IID and the Salton Sea. This analysis is of particular importance because the salinity of the Salton Sea is a primary determinant of the viability of the Salton Sea fishery. The results of the salt budget for the IID are shown in Chapter E.2. Chapter E.3 presents the historical water balance for the Salton Sea, in addition to some past analyses of salt loading to the sea. Chapter E.4 presents the results of the salt budget analysis for the Salton Sea.

This appendix also presents a mathematical model that can be used to predict the future elevation and salinity of the sea. This model is based on the mass balance developed in Chapter E.3 for the historical elevation. Based on the analyses of salt loading, this model was used to predict future salinities (measured by total dissolved solids) of the sea. These results are presented in Chapter E.5.

CHAPTER E.2

SALT BUDGET FOR IMPERIAL IRRIGATION DISTRICT

The salt budget discussed herein relies on the measurements of the flow and total dissolved solids (TDS) reported by the IID, U.S. Geological Survey (USGS), California Department of Water Resources (DWR), and Parsons.

E.2.1 DATA SOURCES

The historical TDS data reported by different investigators has not been systematic and continuous. Commonly, one to three measurements represent a full year. Most references have used salinity and TDS interchangeably. Salinity (as used in ocean studies) is defined as the total amount of solid material in grams contained in 1 kg of water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all organic matter completely oxidized. Salinity is used in a more general sense, however, to refer to the total dissolved mineral content of a water body. TDS is defined as organic and inorganic molecules and ions that are present in true solution in water that remain as residue after evaporation at 180°C (105°C prior to January 1970).

In this report, salt concentration is expressed in terms of TDS in milligram per liter (mg/L) or ton per acre-foot (ton/AF). The relationship between mg/L and ton/AF is:

$$\text{mg/L} = \text{ton/AF} \times 735.46$$

Flow measurements are reported by the USGS for different surface flows on a monthly and annual (total) basis. The TDS for the New and Alamo Rivers are measured by the DWR three or four times a year at selected stations.

The data used in this report is from the following stations (Figure E.2-1):

(1) New River at International Boundary (flow and TDS)
(2) Alamo River at International Boundary (flow and TDS)
(3) New River near Westmorland (flow and TDS)
(4) Alamo River near Calipatria (TDS)
(5) Alamo River near Niland (flow)

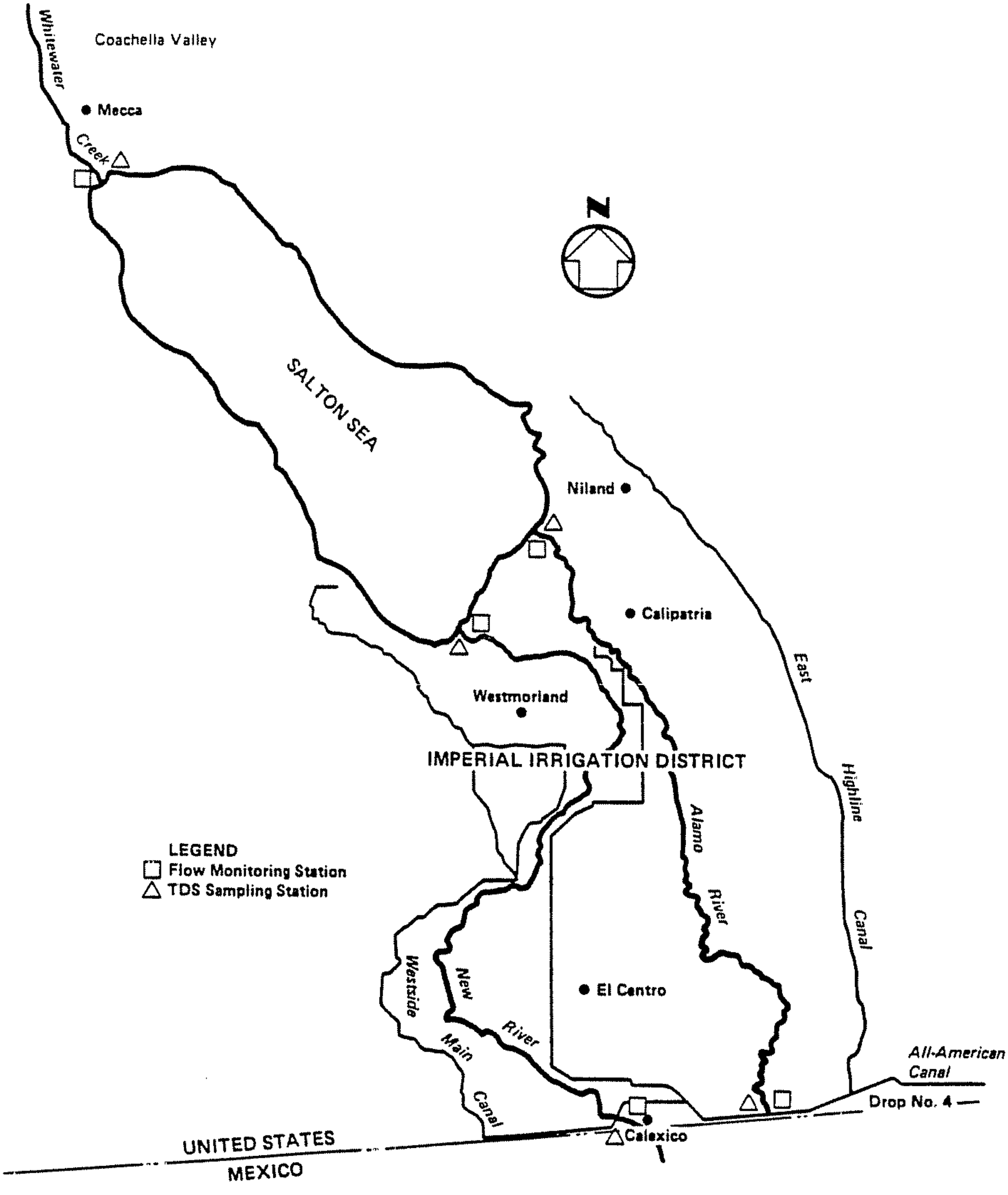


Figure E.2-1 - Location of Field Stations on New, Alamo, and Whitewater Rivers (Parsons, 1986)

E.2.2 IID WATER BALANCE

The water balance equation was assumed to be inflow = outflow + consumption (including evaporation). Inflow consists of surface flows, subsurface flows, and precipitation. It is assumed that, within the IID area, groundwater storage change is negligible.

Table E.2-1 presents the annual water balance for the IID for each year from 1975-1984. The inflow to the IID is represented by inflow from Mexico in the New and Alamo Rivers measured at the USGS stations at the International Boundary, flow of the All-American Canal at Drop No. 4, subsurface inflow, and precipitation. Subsurface inflow was assumed to be constant for each year and consisted of 54,000 AF/year seepage from the Coachella Canal, 15,000 AF/year subsurface inflow from the west side of the Salton Sea, and 7,000 AF/year subsurface inflow from Mexico (Parsons, 1985a). It was assumed that this contributes no net salt inflow to the IID. Outflow consists of surface flows of the New and Alamo Rivers discharging to the Salton Sea, flows in irrigation drains that discharge directly into the Salton Sea, and a very small subsurface outflow (2,000 AF/year). Figure E.2-2 shows the total inflow to the IID, outflow from the IID, and flow of the All-American Canal at Drop No. 4.

E.2.3 IID SALT BUDGET

The TDS values for each inflow and outflow are shown in Table E.2-2. Because the total salt input (and output) is the product of the TDS and flow, the annual variations in input and output depend on both the TDS and flow variations. No trend is apparent in the TDS values from different flows; the TDS values for subsurface inflows and direct drainages are not known. A major part of the subsurface inflow is the seepage from the Coachella Canal that occurred prior to lining and is still flowing to the sea. Therefore, the TDS for subsurface flows were assumed to be the same as the TDS for the All-American Canal. This is a simplification, however, because the seepage from the Coachella Canal may be causing higher salinity groundwater to flow up into the soil and drainage system. Because of the lack of data, it was assumed that the Coachella Canal seepage had the same TDS as had the All-American Canal. This introduces negligible error because subsurface salt input and output turn out to be very minor compared to the total. Direct drainages were assumed to have the same TDS as the Alamo River (near the outlet). This is a valid assumption because almost all of the water in the Alamo River is drainage water from the IID.

Table E.2-3 represents the annual salt budget for the IID for each year from 1975-1984. Salt input to the IID ranges from 3,616,000 tons in 1978 to 4,238,000 tons in 1981. Salt output ranges from 4,549,000 tons in 1975 to 5,358,000 tons in 1982. Table E.2-3 indicates a favorable salt balance in the IID area. More salt is removed each year from the IID than is brought in. The net salt loss from the IID ranges from 343,000 tons in 1975

Table E.2-1 - IID Water Balance (1,000 AF)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Inflow										
New River from Mexico[a]	100	103	108	99	145	156	155	157	243	268
Alamo River from Mexico[a]	1	1	1	1	1	2	2	2	2	2
All-American Canal at Drop No. 4[b]	2,934	2,741	2,664	2,638	2,787	2,731	2,731	2,492	2,385	2,611
Subsurface inflow[c]	76	76	76	76	76	76	76	76	76	76
Precipitation[d]	70	268	258	217	116	215	125	250	287	169
Total	3,181	3,189	3,107	3,031	3,125	3,180	3,089	2,977	2,993	3,126
Use[d]										
Crops consumptive use[e]	1,805	1,827	1,807	1,758	1,763	1,811	1,811	1,760	1,705	1,807
Other consumptive use[f]	34	36	36	38	40	38	37	36	35	36
Water surface evaporation	30	30	30	30	30	30	30	31	31	31
Consumptive use by native vegetation	13	38	35	41	20	30	21	34	41	18
Consumptive use by phreatophytes	67	67	67	67	67	67	67	67	67	67
Total	1,949	1,998	1,975	1,934	1,920	1,976	1,966	1,928	1,879	1,959
Outflow										
New River at Salton Sea[a]	435	435	413	393	458	455	433	416	477	512
Alamo River at Salton Sea[b]	682	639	615	603	635	642	592	543	552	564
Direct drainage to Salton Sea[g]	113	115	102	99	110	105	96	88	83	89
Subsurface outflow	2	2	2	2	2	2	2	2	2	2
Total	1,232	1,191	1,132	1,097	1,205	1,204	1,123	1,049	1.114	1,167

[a] USGS gauges.
[b] There is an estimated inflow of 25,000 AF/year from seepage recovery that is not included in water flowing into the IID (Parsons, 1985a).
[c] Includes 54,000 AF from the Coachella Canal, 15,000 AF from the west side, and 7,000 AF from Mexico.
[d] Parsons, 1985a.
[e] Closure term in hydrologic balance.
[f] Includes water used by municipals, rural residentials, industrials, geothermal facilities, schools, cemetaries, sports and recreational facilities, feedlots, and other miscellaneous service pipes.
[g] Direct flow from 36 irrigation drains (Parsons, 1985a).
Source: Parsons, 1986.

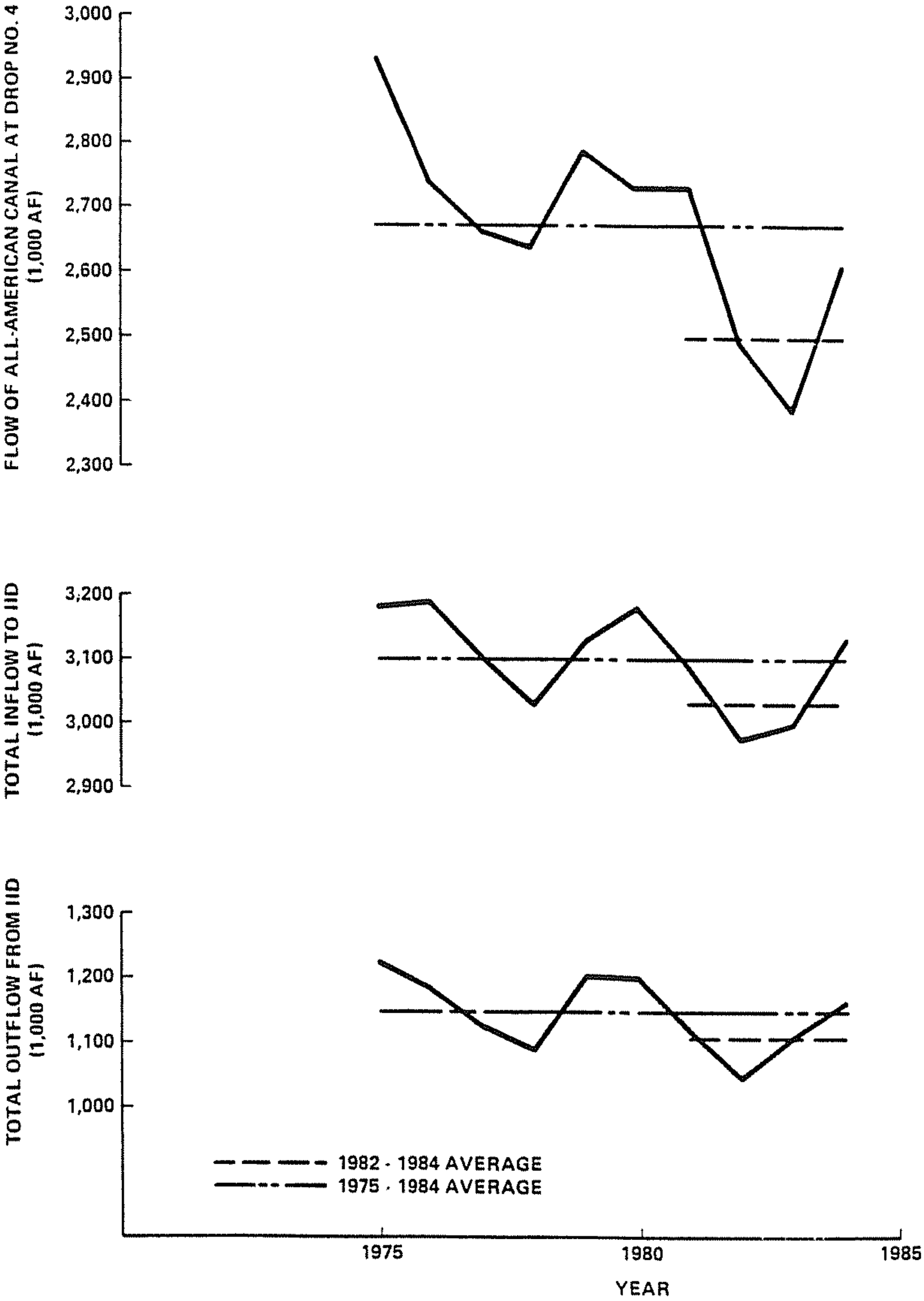


Figure E.2-2 - Total Outflow from IID, Inflow to IID, and Flow of All-American Canal at Drop No. 4 (Parsons, 1985a)

Table E.2-2 - TDS of Surface Waters (mg/L)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
All-American Canal at Drop No. 4[a]	875	860	831	797	843	812	847	853	772	737
New River at International Boundary[b]	4,537	5,113	4,491	4,982	4,375	4,290	4,683	4,190	3,553	3,223
Alamo River at International Boundary[b]	3,279	2,870	4,182	3,478	2,885	3,498	4,140	3,840	3,958	4,365
New River near Westmorland[b]	3,287	3,576	3,731	3,646	3,435	3,498	3,703	4,065	3,410	3,213
Alamo River near Calipatria[b]	2,402	2,505	2,944	2,797	2,780	2,664	2,803	3,545	2,803	3,033

[a] IID Water Reports (1975-1984).
[b] DWR, 1985.
Source: Parsons, 1986.

Table E.2-3 - IID Salt Inflow and Outflow (1,000 tons)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Inflow										
New River from Mexico	616	716	658	667	863	912	990	895	1,173	1,175
Alamo River from Mexico	7	4	8	6	6	8	13	11	10	11
All-American Canal at Drop No. 4	3,493	3,207	3,012	2,861	3,197	3,017	3,147	2,892	2,505	2,618
Subsurface inflow	90	89	86	82	87	84	88	88	80	76
Total	4,206	4,016	3,764	3,616	4,153	4,021	4,238	3,886	3,768	3,880
Outflow										
New River at Salton Sea	1,943	2,117	2,096	1,950	2,139	2,163	2,183	2,302	2,215	2,239
Alamo River at Salton Sea	2,230	2,178	2,463	2,295	2,402	2,325	2,256	2,622	2,105	2,327
Direct drainage to Salton Sea	369	392	409	377	416	381	366	424	317	367
Subsurface outflow	7	7	8	8	8	7	8	10	8	8
Total	4,549	4,694	4,976	4,630	4,965	4,876	4,813	5,358	4,645	4,941
Net salt loss	343	678	1,212	1,014	812	855	575	1,472	877	1,061

Source: Parsons, 1986.

to 1,472,000 tons in 1982. Major sources of this salt are shallow groundwater rising above the tile system and salt leached from the soil. Other sources such as fertilizer added to the soil in agricultural practices and wastewaters from industrial and municipal sources have minimal input to the TDS leaving the IID. Approximately 60,000-70,000 tons of fertilizer are used each year in the IID's area. Municipal and industrial wastewater account for less than 3% of effluent water flowing from the IID. Table E.2-4 shows the 3-year average, 10-year average, and total values for water and salt input and output from 1975-1984. In the last 10 years, 8,900,000 tons of salt has been removed from the IID area (net removal greater than salt inflow).

Table E.2-4 - Summary of IID Water and Salt Inflow and Outflow

	Average 1982-1984		Average 1975-1984		Total 1975-1984	
	Flow (1,000 AF)	Salt Load (1,000 tons)	Flow (1,000 AF)	Salt Load (1,000 tons)	Flow (1,000 AF)	Salt Load (1,000 tons)
Inflow						
New River from Mexico	223	1,081	153.4	866.5	1,534	8,665
Alamo River from Mexico	2	11	1.5	8.4	15	84
All-American Canal at Drop No. 4	2,496	2,671.7	2,671.4	2,994.9	26,714	29,949
Subsurface inflow	76	81.3	76	85	760	850
Precipitation	235	0	197.5	0	1,975	0
Total	3,032	3,845	3,099.8	3,954.8	30,998	39,548
Outflow						
New River at Salton Sea	468	2,252	442.7	2,134.7	4,427	21,347
Alamo River at Salton Sea	553	2,351	606.7	2,320.3	6,067	23,203
Direct drainage to Salton Sea	87	369	100	381.8	1,000	3,818
Subsurface outflow	2	9	2	8	20	80
Total	1,110	4,981	1,151.4	4,844.8	11,514	48,448
Net salt loss		1,136		890		8,900

Source: Parsons, 1986.

CHAPTER E.3

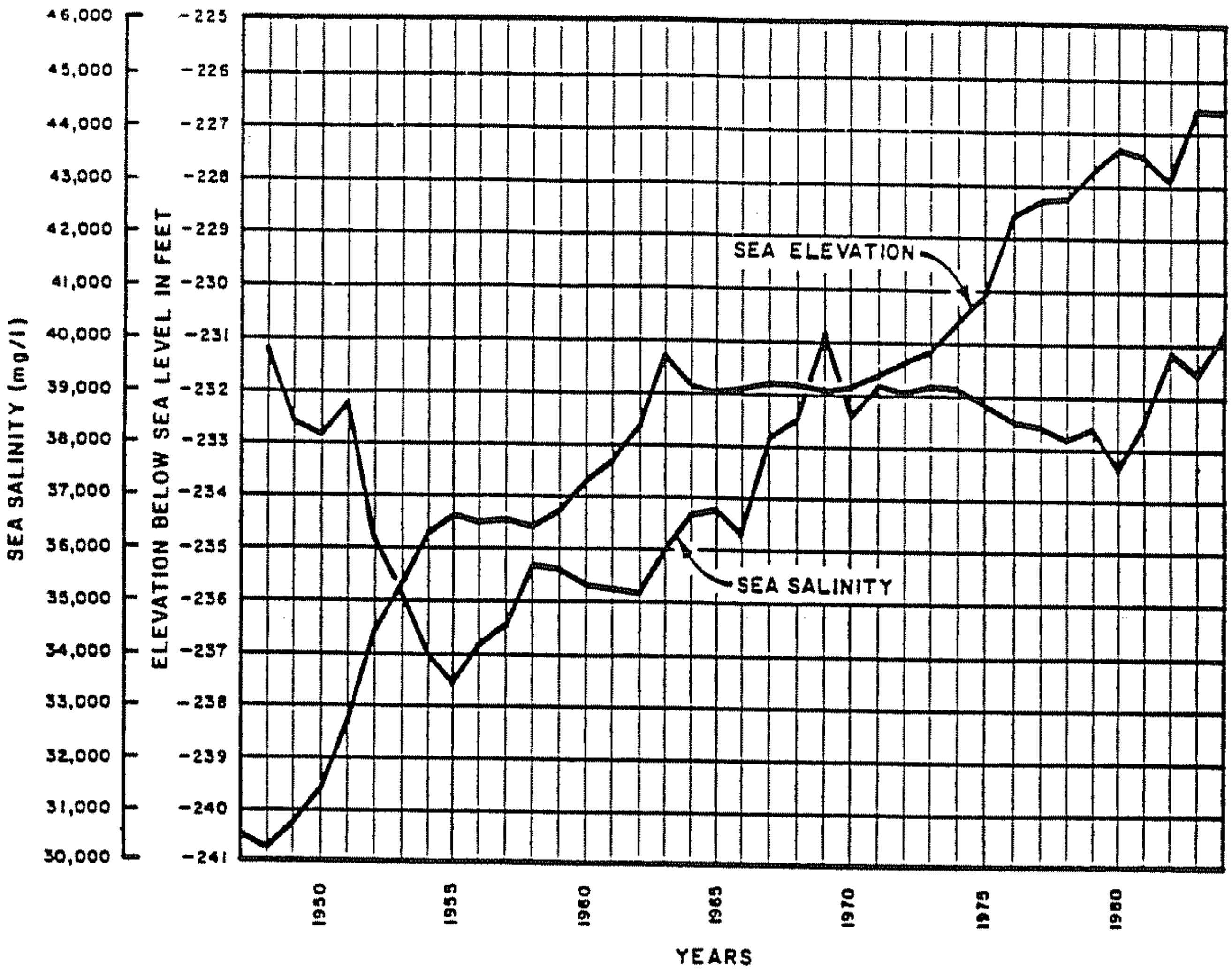
HISTORICAL SALTON SEA

E.3.1 INTRODUCTION

The Salton Sea is a lake formed in an internally drained basin comprised of 8,300 mi^2, of which 1,000 mi^2 are located in Baja California, Mexico. Thus, the sea is a natural sump, sustained in recent times primarily from agricultural runoff from the Imperial and Coachella Valleys, and Mexico. The Salton Sea was formed initially in 1905-1907 when the Colorado River was breached near Yuma and flowed unimpeded into the Salton Trough. The initial filling period was followed by a period of sharp decline before irrigation return flows increased to the point where the level of the sea gradually increased. The sea is recognized, therefore, as a depository for irrigation waste. A series of land withdrawals by the federal government resulted in the withdrawal of all public land below elevation -220 ft for this purpose. Additional private land and flood easements owned by the IID are located below this elevation.

The salinity of the Salton Sea has been generally increasing over the life of the sea. The initial salinity is a result of the dissolution of salts within the sea floor. The continued rise in the salinity is a result of the inflow of water with fairly high TDS and the very high evaporation rate. The only outflow is by evaporation. Thus, the salinity is a function of the degree to which inflow balances outflow. In years of very high inflow, the salinity of the sea may decrease because the evaporation is significantly less than the diluting effect of the inflow. The present day salinity is approximately 40,000 ppm (see Appendix F).

The historical change in elevation and salinity of the sea is shown in Figure E.3-1. Although not shown in this figure, significant monthly changes in elevation occur as a result of a seasonal variation in surface inflow and evaporation. This variation may range from approximately 0.5 to 1.0 ft within 1 year. The variation in elevation and salinity is dependent on the natural variation in evaporation, direct rainfall and storm runoff, and the manmade variation in the irrigation return flows. The general trend, however, has been an increase in both the elevation of the sea and its salinity. Although most of inflow is due to irrigation drainage, storm runoff may contribute as much as 1.5 ft/year increase to the elevation of the sea.



NOTES

1. END OF YEAR ELEVATIONS NEAR FIG TREE JOHN SPRING.(I.I.D. DATA)

2. AVERAGE OF SAMPLES AT FOUR OR FIVE STATIONS TAKEN IN MAY AND NOVEMBER BY I.I.D.

Figure E.3-1 - Historical Change in Salton Sea Salinity and Elevation (B-E, 1983a)

E.3.2 HISTORICAL WATER BALANCE

A schematic diagram of the water inflow and outflow through the Imperial Valley to the Salton Sea (Figure E.3-2) forms the basis for the water balance analysis. The historical Salton Sea water budget is presented in Table E.3-1 for years 1950-1984. The average inflow to the sea during this period was approximately 1,368,000 AF/year as derived from Table E.3-2. This inflow is based on measured flow data where possible, e.g., the New and Alamo Rivers and large drains are gauged at their outflow to the Salton Sea. However, the remaining drains and minor tributaries must be estimated. Estimates of subsurface inflow to the sea were also made and are discussed in more detail in the Water Requirements and Availability Study (Parsons, 1985a).

The value for the component from the Coachella Canal should be noted. This value has remained approximately the same (54,000 AF/year) since 1965. This value is considerably lower than the 130,000 AF/year estimated to have seeped from the Coachella Canal prior to 1981, when a portion of the Coachella Canal was lined (USBR, 1984). Although this seepage has created a significant groundwater mound along the Coachella Canal, the underlying geology and soils constrain the flow of this water to the Salton Sea at approximately 54,000 AF/year. Direct rain to the sea contributes another 44,500 AF/year, and water loss is approximately 1,326,000 AF/year via evaporation. The elevation of the sea has thus increased from -240.2 ft in 1949 to -226.7 ft in 1984.

The IID is the largest contributor of flows to the Salton Sea. Other flows come from Mexico via the New and Alamo Rivers, the Coachella Valley, and miscellaneous other flows, including washes flowing directly to the sea. The distribution of inflow is presented in Table E.3-3. This historical data shows several trends:

(1) The contribution from the IID has decreased in recent years. The present day inflow is running at about 810,000 AF/year, a significant decrease from the 33-year average of 994,000 AF/year.

(2) The input from Mexico has increased steadily in recent years to its present level of around 250,000 AF/year.

(3) The inflow from the Coachella Valley also increased but is now fairly stable at about 208,000 AF/year.

(4) The remaining inflow is more variable, reflecting the variation in rainfall and runoff patterns. The long-term average for this period is 95,000 AF/year. It must be noted that this value is the closure term from the Salton Sea water balance. It is thus the most uncertain term, reflecting not only runoff but errors in computation. Major sources of error may be in the unmeasured runoff

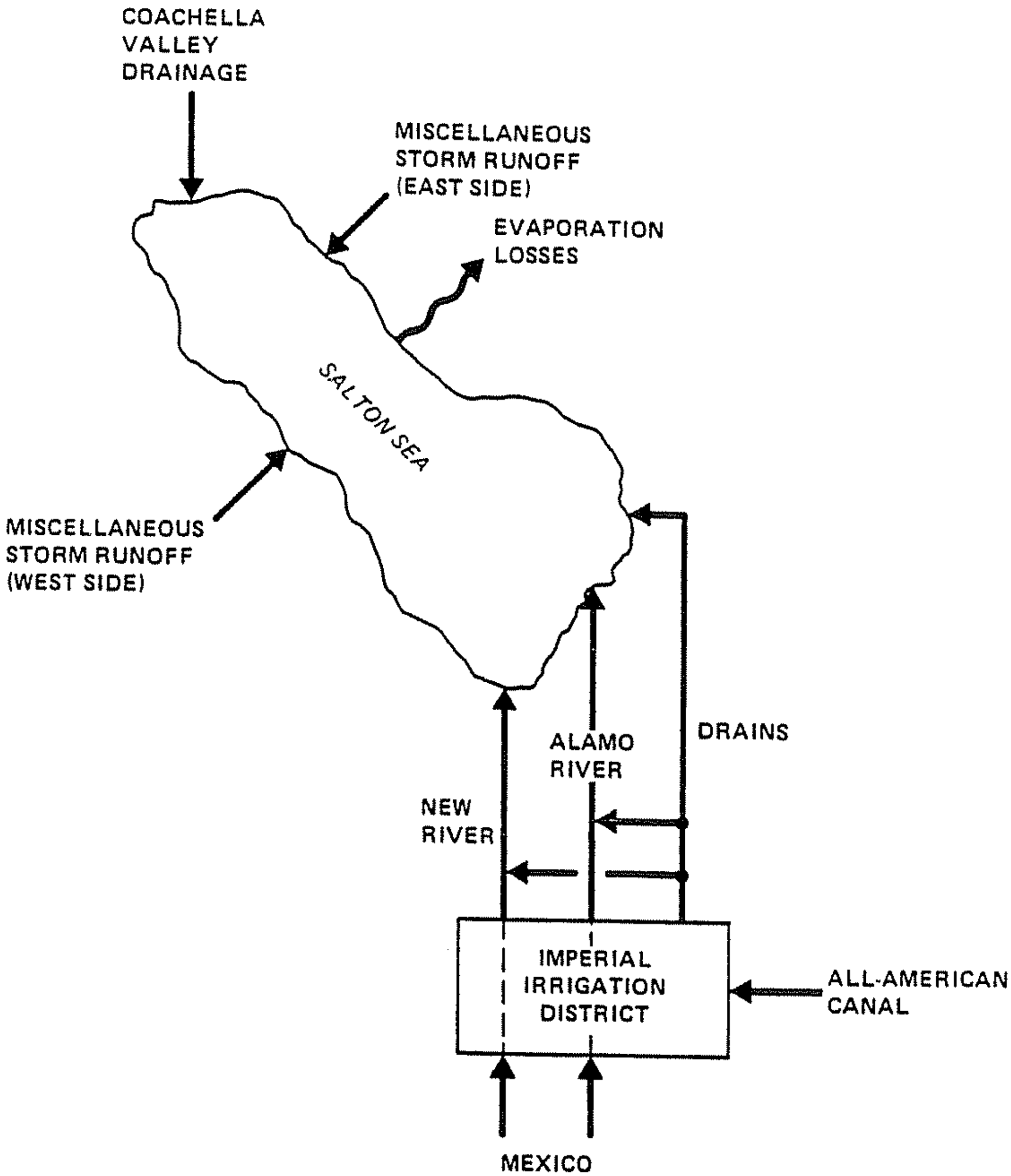


Figure E.3-2 - Diagram of Flows to the Salton Sea
(Parsons, 1986)

Table E.3-1 - Historical Salton Sea Water Budget

Year[a]	Elevation Below Sea Level (ft)[b]	Surface Area (1,000 acres)[c]	Water Balance (1,000 AF)			Change in Storage[g]
			Inflow[d]	Direct Rain[e]	Evaporation[f]	
1949	240.2	-	-	-	-	
1950	239.6	198	1,203	4	1,090	+117
1951	238.3	204	1,358	30	1,160	+228
1952	236.6	211	1,411	45	1,140	+316
1953	235.8	216	1,456	1	1,260	+197
1954	234.8	221	1,365	24	1,170	+219
1955	234.4	223	1,371	18	1,290	+99
1956	234.5	222	1,310	2	1,330	-18
1957	234.5	222	1,193	33	1,210	+16
1958	234.6	222	1,187	40	1,230	-3
1959	234.3	223	1,300	33	1,280	+53
1960	233.8	224	1,387	36	1,310	+113
1961	233.4	225	1,413	34	1,360	+87
1962	232.7	227	1,469	23	1,330	+162
1963	231.2	231	1,644	57	1,380	+321
1964	231.9	230	1,212	10	1,357	-135
1965	232.0	229	1,164	49	1,259	-46
1966	232.0	229	1,312	19	1,308	+23
1967	231.8	230	1,321	59	1,335	+45
1968	231.8	230	1,399	31	1,430	0
1969	232.0	230	1,392	22	1,414	0
1970	231.9	230	1,270	21	1,291	0
1971	231.7	231	1,309	23	1,263	+69
1972	231.3	232	1,317	25	1,264	+78
1973	231.2	233	1,354	18	1,310	+62
1974	230.7	234	1,446	56	1,388	+114
1975	230.1	236	1,475	14	1,337	+152
1976	228.6	239	1,490	144	1,329	+305
1977	228.3	240	1,466	67	1,461	+72
1978	228.2	240	1,507	125	1,629	+3
1979	227.8	242	1,593	74	1,563	+104
1980	227.3	243	1,475	89	1,448	+116
1981	227.4	242	1,292	49	1,385	-44
1982	227.6	242	1,194	63	1,300	-43
1983	226.6	244	1,485	165	1,407	+243
1984	226.7	244	1,329	55	1,408	-24
Average	231.9	229.1	1,368	44.5	1,326	

[a] Calendar year.
[b] IID record of station Near Fig Tree John Spring.
[c] Salton Sea area in thousands of acres.
[d] Computed inflow to balance hydrologic equation. Inflow equals change in storage plus evaporation less direct rainfall.
[e] Direct rain is computed as area times average rainfall as measured at three stations near the sea.
[f] Evaporation is pan evaporation (average of three stations) times pan coefficient of 0.69 times surface area.
[g] Determined from change in elevation and area-capacity relationship.
Source: Parsons, 1985a.

Table E.3-2 - Derivation of Inflow Components to Salton Sea (1,000 AF)

	Imperial Valley					Coachella Valley		
Year[a]	Measured and Estimated Inflow in New and Alamo Rivers and Vicinity[b] (1)	Less Inflow from Mexico[c] (2)	Less Component from Coachella Canal[d] (3)	Less Subsurface Inflow from West[e] (4)	Total IID Inflow[f] (5)	Inflow[g] (6)	Plus Coachella Canal[h] (7)	Total Inflow[i] (8)
1950	1,145	45	-	15	1,085	65	8	73
1951	1,208	44	-	15	1,149	108	8	116
1952	1,300	44	-	15	1,241	86	8	94
1953	1,380	39	-	15	1,326	63	8	71
1954	1,306	38	0	15	1,253	72	8	80
1955	1,121	56	5	15	1,045	85	13	98
1956	1,172	85	10	15	1,062	71	18	89
1957	1,086	80	15	15	976	53	23	76
1958	1,082	113	20	15	934	56	28	84
1959	1,147	131	25	15	976	57	33	90
1960	1,184	130	29	15	1,011	70	37	107
1961	1,170	124	34	15	997	84	42	126
1962	1,225	141	39	15	1,030	113	47	160
1963	1,297	148	44	15	1,090	133	52	185
1964	1,013	113	49	15	836	121	57	178
1965	998	120	54	15	809	137	62	199
1966	1,112	112	54	15	931	131	62	193
1967	1,128	105	54	15	954	129	62	191
1968	1,110	114	54	15	927	136	62	198
1969	1,070	112	54	15	889	142	62	204
1970	1,124	108	54	15	947	130	62	192
1971	1,204	116	54	15	1,019	138	62	200
1972	1,179	120	54	15	990	148	62	210
1973	1,186	126	54	15	991	163	62	225
1974	1,238	120	54	15	1,049	157	62	219
1975	1,231	108	54	15	1,054	174	62	236
1976	1,291	111	54	15	1,011	175	62	237
1977	1,132	116	54	15	947	157	62	219
1978	1,098	107	54	15	922	144	62	206
1979	1,205	153	54	15	983	151	62	213
1980	1,203	185	54	15	969	144	62	206
1981	1,123	165	54	15	889	157	62	219
1982	1,050	166	54	15	815	152	62	214
1983	1,114	252	54	15	793	151	62	213
1984	1,167	277	54	15	821	141	62	203

[a] Calendar year.
[b] Measured flow in New and Alamo Rivers at Salton Sea plus inflow from drains flowing directly sea, plus subsurface flow.
[c] Measured surface flow of New and Alamo Rivers at International Boundary, plus subsurface flow.
[d] Portion of seepage from Coachella Canal estimated to enter Salton Sea via Imperial Valley.
[e] Subsurface flow entering IID from west, which is intercepted by drainage systems.
[f] Column 1, less columns 2, 3, and 4.
[g] Coachella inflow as reported by USGS (1950-1972). From 1973, amount taken from Coachella Valley Water District data and is drainage water and operational discharge from Coachella Valley.
[h] Column 3, plus estimated inflow north of IID (Hely et al., 1966).
[i] Sum of columns 6 and 7.
Source: Parsons, 1985a.

Table E.3-3 - Components of Inflow to Salton Sea (1,000 AF)

Year[a]	IID[b]	Mexico[c]	Coachella[d]	Other[e]	Total[f]
1950	1,085	45	73	0	1,203
1951	1,149	44	116	49	1,358
1952	1,241	44	94	32	1,411
1953	1,326	39	713	0	1,456
1954	1,253	38	80	-6	1,365
1955	1,045	56	98	172	1,371
1956	1,062	85	89	74	1,310
1957	976	80	76	61	1,193
1958	934	113	84	56	1,187
1959	976	131	90	103	1,300
1960	1,011	130	107	139	1,387
1961	997	124	126	166	1,413
1962	1,030	141	160	138	1,469
1963	1,090	148	185	221	1,644
1964	836	113	178	85	1,212
1965	809	120	199	36	1,164
1966	931	112	193	76	1,312
1967	954	105	191	71	1,321
1968	927	114	198	160	1,399
1969	889	112	204	187	1,392
1970	947	108	192	23	1,270
1971	1,019	116	200	-26	1,309
1972	990	120	210	-3	1,317
1973	991	126	225	12	1,354
1974	1,049	120	219	58	1,446
1975	1,054	108	236	77	1,475
1976	1,011	111	237	131	1,490
1977	947	116	219	184	1,466
1978	922	107	206	272	1,507
1979	983	153	213	244	1,593
1980	969	165	206	135	1,475
1981	889	165	219	19	1,292
1982	815	166	214	-1	1,194
1983	793	252	213	227	1,485
1984	821	277	203	28	1,329

[a] Calendar year.
[b] Amount as determined by IID adjusted for Coachella Canal seepage. The amount includes measured inflow in New and Alamo Rivers, less surface and subsurface inflow from Mexico measured at the International Boundary, plus estimated inflow from drains that empty directly to the sea. An allowance was deducted for the Coachella Canal seepage entering the Salton Sea via the IID. This amount was assumed to vary from 0 AF in 1954 to 54,000 AF in 1965 and thereafter.
[c] Inflow in New and Alamo Rivers measured at International Boundary, plus subsurface inflow.
[d] Values include allowance for Coachella Canal seepage entering Salton Sea via the IID as noted in footnote b, above. The direct Coachella inflow was that reported by the USGS (1950-1972). From 1973 through 1984, amounts are from the CVWD.
[e] Amount to balance table and includes storm inflow and subsurface inflow.
[f] Total inflow computed from water balance of Salton Sea.
Source: Parsons, 1985a.

and in the actual evaporation from the Salton Sea. Although a pan coefficient of 0.69 is the best estimate available, the actual ratio between Salton Sea evaporation and pan evaporation is likely to be more variable.

E.3.3 HISTORICAL SALT LOADING

The salinity of the sea has increased as a result of evaporation, in addition to the inflow of salt. Several estimates of salt loading have been made and range from 3.67 to 5.04 million tons/year as shown in Table E.3-4. These figures demonstrate an increase in salt input in recent years. The average of all these figures is approximately 4.27 million tons/year. These are estimates from previous studies and are presented for comparison with the salt analyses presented in Chapter E.4.

Table E.3-4 - Historic Salt Loading: Salton Sea

Salt Loading (million tons/year)	Time Period
3.95[a]	1948-1962
3.67[b]	1945-1963
4.44[a]	1963-1972
5.04[c]	1963-1980

[a] U.S. Department of the Interior and the State of California Resources Agency, 1974b.
[b] Hely et al., 1966.
[c] USBR, 1981b.
Source: Parsons, 1985a.

CHAPTER E.4

SALT BUDGET FOR SALTON SEA

E.4.1 METHODOLOGY

The purpose of this analysis is to present the historic salt loading to the Salton Sea between 1975 and 1984. The methodology was developed to analyze the salt quantities on a yearly basis. Water and salt inflow data to the IID are discussed in previous chapters. Salt loading from the Coachella Valley was calculated from the TDS values measured by the DWR in the Whitewater River near Mecca (see Figure E.2-1).

Two different approaches were used to estimate the salt budget for the Salton Sea:

(1) Total salt loading of the sea based on observed (measured) TDS in the sea.

(2) Total salt loading of the sea based on total salt input.

For both cases, the hydrological balance was calculated using area-capacity equations based on observed elevation (see Chapter E.5). By using the elevation-volume relationship, the errors caused by uncertainties in inflow-outflow model are eliminated; however, the application of the empirical equation may introduce new errors that may reduce the precision or accuracy of the salt content predictions.

E.4.2 SALT BUDGET

Table E.4-1 shows the components of water and salt inflow from the IID, Mexico, and the Coachella Valley to the Salton Sea. On the average, based on total salt input estimates, more than 5.2 million tons of salt are added to the sea every year.

Table E.4-2 shows the TDS observed from 1975-1984. The TDS values reported by the IID are measured from surface water samples taken at five stations: Bertram Station, Desert Ranch, Sandy Beach, Salton Sea Beach, and between the Alamo and New River outlets (Figure E.4-1). For each year, the average TDS value was calculated from values reported for samples taken from the first four stations. Results from samples taken between the Alamo and New River outlets were excluded because of the possible dilution effect of water from the rivers. The annual fluctuation in TDS is shown in Figure E.4-2.

Table E.4-1 - Historical Inflow to Salton Sea

Year	From IID and Mexico Flow (1,000 AF)	From IID and Mexico Salt Load (1,000 tons)	From Coachella Valley Flow[a] (1,000 AF)	From Coachella Valley Salt Load[b] (1,000 tons)	Total from IID, Mexico, and Coachella Valley Flow (1,000 AF)	Total from IID, Mexico, and Coachella Valley Salt Load (1,000 tons)
1984	1,167	4,941	149	355	1,316	5,296
1983	1,114	4,645	159	387	1,273	5,032
1982	1,049	5,358	160	416	1,209	5,774
1981	1,123	4,813	165	445	1,288	5,258
1980	1,204	4,876	152	362	1,356	5,238
1979	1,205	4,965	159	426	1,364	5,391
1978	1,097	4,630	152	377	1,249	5,007
1977	1,132	4,976	165	399	1,297	5,375
1976	1,191	4,694	183	420	1,374	5,114
1975	1,232	4,549	182	358	1,414	4,907
average (1975-1984)	1,151	4,845	163	394	1,314	5,239

[a] Values exclude Coachella Canal seepage entering the Salton Sea via the IID.
[b] TDS values from the DWR, 1985.
Source: Parsons, 1985a.

Table E.4-2 - Average TDS of Salton Sea[a]

Year	Mid-Year Average[b]		End-of-Year Average[c]		Combined Average	
	mg/L	tons/AF	mg/L	tons/AF	mg/L	tons/AF
1984	39,833	54.16	40,838	55.53	40,335	54.84
1983	39,270	53.39	39,689	53.96	39,479	53.68
1982	39,181	53.27	40,625	55.24	39,897	54.25
1981	37,411	50.87	39,490	53.69	38,451	52.28
1980	37,153	50.52	38,070	51.77	37,616	51.15
1979	37,849	51.46	38,997	53.02	38,423	52.24
1978	37,342	50.77	38,940	52.95	38,141	51.68
1977	NA	NA	38,461	52.29	38,461	52.29
1976	38,106	51.81	38,950	52.96	38,528	52.39
1975	37,955	51.61	39,990	54.37	38,973	52.99
average (1975-1984)	38,233	51.98	39,404	53.58	38,817	52.78

NA = not available.
[a]Average values for samples taken at four stations: Bertram Station, Desert Beach, Sandy Beach, and Salton Sea Beach.
[b]Samples taken in May of each year.
[c]Samples taken in November of each year.
Source: IID Water Reports, 1975-1984.

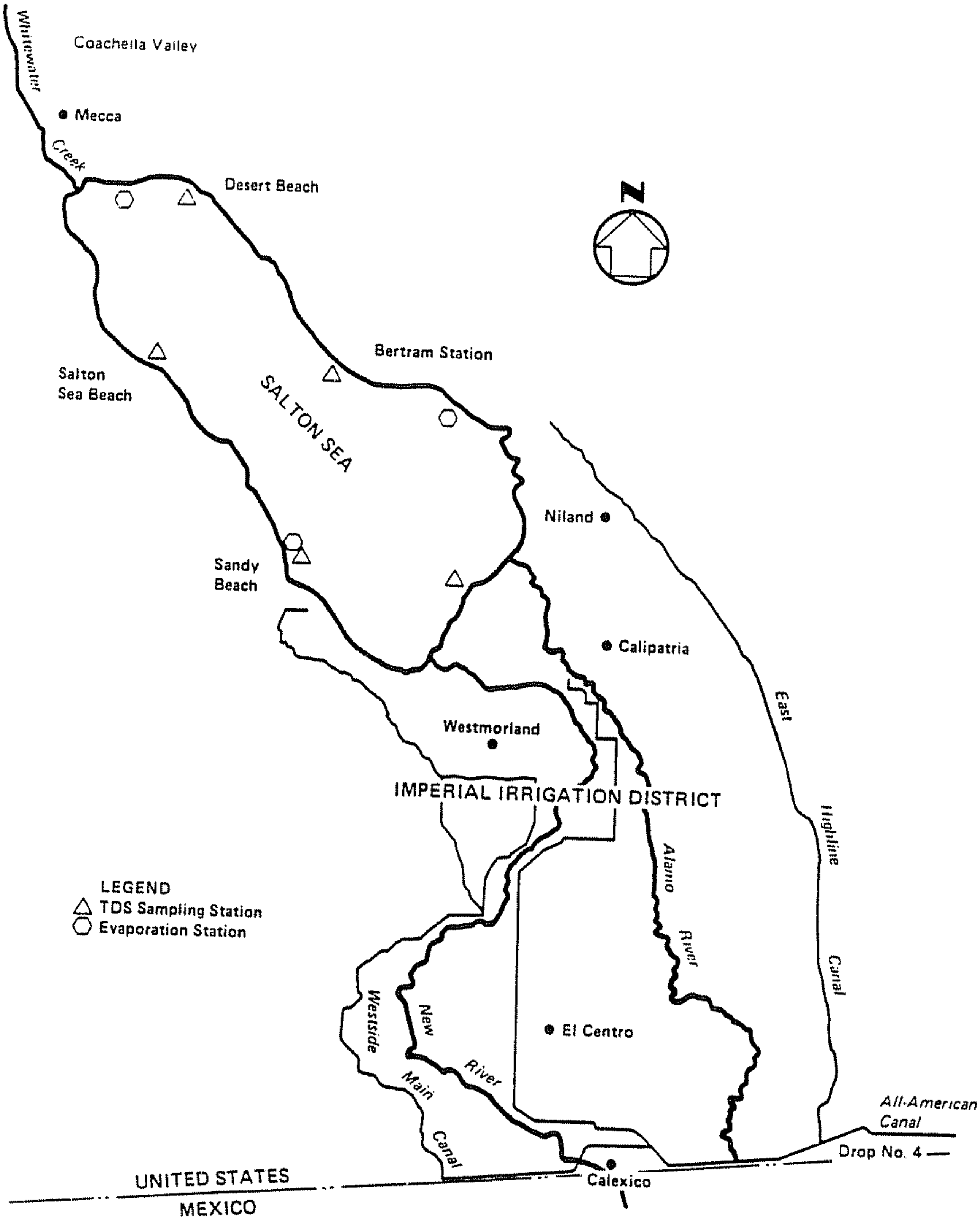


Figure E.4-1 - Location of Field Stations on the Salton Sea (Parsons, 1986)

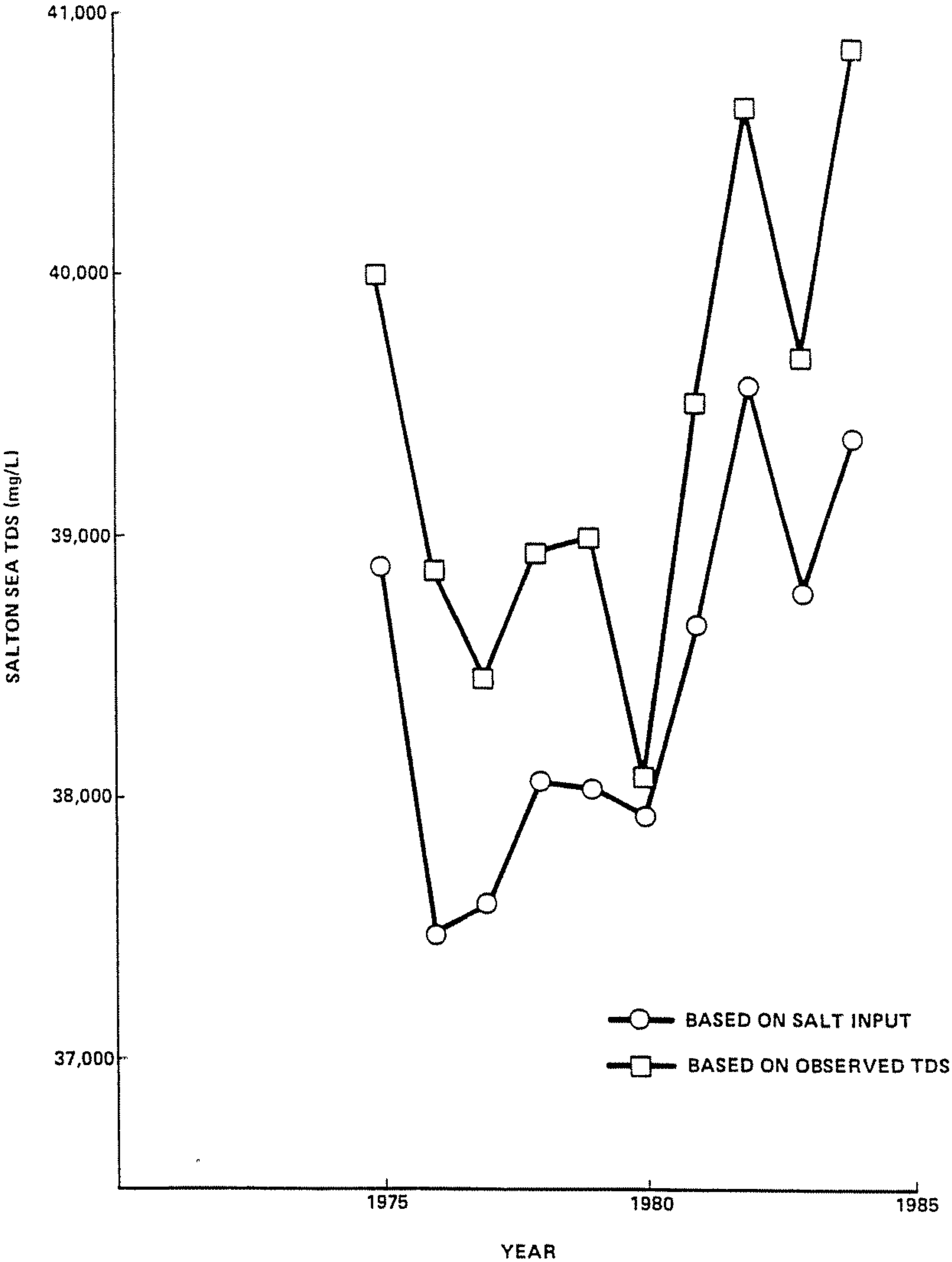


Figure E.4-2 - TDS of the Salton Sea
(Parsons, 1986)

Table E.4-3 shows the historical salt budget for the Salton Sea (1975-1984), based on the observed TDS. Sea volumes are calculated from the empirical equation. Negative salt gains are caused by errors in the hydrology equation and errors in the TDS measurements. Table E.4-3 shows that the Salton Sea water contains about 405 million tons of dissolved salt. This approach demonstrates that, based on the differences between 1974 and 1984, approximately 6.6 million tons of salt are added to the sea every year. However, errors in the yearly TDS and the volume determinations make this a somewhat biased estimate. A more accurate estimate of the salt loading based on TDS is obtained by a regression analysis of the total Salton Sea salt content. This is shown in Figure E.4-3 as the slope of the regression line fitted to this data and is equal to 5.39 million tons/year. Major sources of error in these calculations may include errors of TDS measurement and errors involved with yearly variations.

Table E.4-3 - Salton Sea Salt Budget
(based on observed TDS)

Year	TDS[a] (tons/AF)	Total Salt[a] Content (1,000 tons)	Salt Gain/Loss During Year (1,000 tons)
1984	55.53	405,250	10,797
1983	53.96	394,453	2,790
1982	55.24	391,663	9,029
1981	53.69	382,634	11,793
1980	51.77	370,841	-2,509
1979	53.02	373,350	6,254
1978	52.95	367,096	5,204
1977	52.29	361,892	-182
1976	52.96	362,074	9,107
1975	54.37	352,967	13,817
average (1975-1984)	53.58	-	6,610

[a] At the end of the year.
Source: Parsons, 1986.

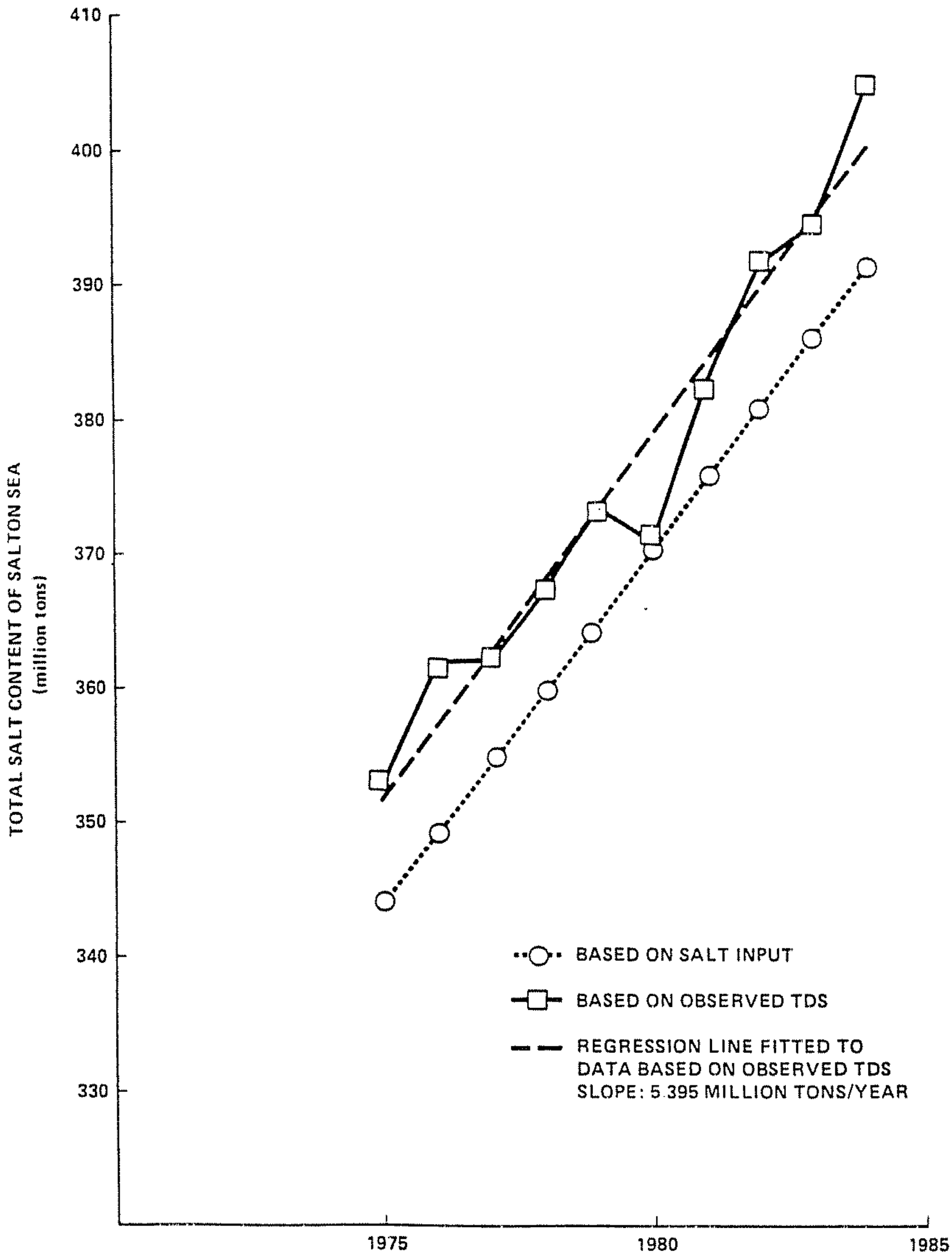


Figure E.4-3 - Salton Sea Salt Content
(Parsons, 1986)

Table E.4-4 presents the estimated salt content and TDS of the Salton Sea, based on the salt input from the IID, Mexico, and the Coachella Valley. It was assumed that there is no other salt input to the sea. The salt content at the end of 1974 was calculated from observed TDS and used as the salt base. This may introduce errors due to uncertainties associated with TDS values as discussed before. The salt content of the Salton Sea at the end of 1984 (as shown by Table E.4-4) is about 392 million tons. This compares with 405 million tons determined from the measured TDS values. The average annual salt input to the sea for 1975-1984 is about 5.2 million tons. This is reasonably close to the 5.4 million tons/year salt loading rate determined by the TDS samples. The predicted TDS concentration at the end of 1984 is estimated to be 39,461 mg/L compared to observed value of 40,838 mg/L. Figure E.4-2 shows the end-of-year average, measured, and calculated TDS. Figure E.4-3 presents the salt content of the Salton Sea from 1975-1984.

Table E.4-4 - Estimated TDS of Salton Sea
(based on salt input)

Year	Salt Added Each Year[a] (1,000 tons)	Total Salt Content (1,000 tons)	TDS	
			tons/AF	mg/L
1984	5,296	391,562	53.65	39,461
1983	5,032	386,266	52.84	38,862
1982	5,774	381,234	53.77	39,545
1981	5,258	374,460	52.68	38,747
1980	5,238	370,202	51.68	38,009
1979	5,391	364,944	51.83	38,116
1978	5,007	359,553	51.86	38,142
1977	5,375	354,546	51.23	37,677
1976	5,114	349,171	51.07	37,562
1975	4,907	344,057	53.00	38,978
1974	-	339,150[b]	-	-
average (1975-1984)	5,239	-	52.36	38,510

[a] From the IID, Mexico, and the Coachella Valley.
[b] 1974 salt content (339,150,000 tons) is based on observed Salton Sea TDS and calculated volume.
Source: Parsons, 1986.

Based on the salt input, the salt budget seems to be more accurate than the salt balance calculated from observed (measured) TDS. This is based on the observation that small errors in the TDS measurements (in combination with small errors in the hydrology equations) can have a very great effect on the determination of annual salt loading (as demonstrated for example by negative salt gains). However, the TDS analysis does help support the salt balance determined by salt input. The major remaining uncertainty in the methodology is the appropriateness of the area-capacity equations. Additional sampling and analyses will be required to resolve these uncertainties.

CHAPTER E.5

SALTON SEA MODELING

E.5.1 MODEL DEVELOPMENT

A computer model was developed to analyze and predict the elevation and salinity of the Salton Sea. The model is based on historical flows and records of precipitation and evaporation near the Salton Sea. Historical analyses of the salt loading to the sea were used to estimate the salt loading effects on the salinity of the Salton Sea.

The model is an input/output model dependent on surface and subsurface inflows. The only outflow of water is by evaporation from the surface of the sea. The water balance for the Salton Sea described in Chapter E.3 was used as the basis for the elevation model. The elevation model was then used as one of the controlling parameters for calculating salinity, along with the yearly salt load to the sea.

Inflow and outflow were computed on an annual basis. The starting elevation each year was used to calculate the surface area of the Salton Sea, which was used, in turn, to calculate the direct rain and evaporation components of the model. Inflow was added to determine the net change in storage for year. This change was then added to the volume at the beginning of the year to determine a year-end volume. This year-end volume was used to calculate the year-end elevation, which became the input for the next year's beginning elevation.

Salinity was modeled in a similar way. The beginning-of-year salinity concentrations were used to calculate the total salt content of the sea, using the volume calculated previously. The salt input to the sea was computed on a yearly basis as a mass-loading rate (tons/year). Assuming conservation of mass, the new salt content was calculated and salinity determined based on the end-of-year volume. A flow diagram summarizing the process for the elevation and salinity model is shown in Figure E.5-1.

E.5.1.1 ELEVATION-AREA-VOLUME RELATIONSHIPS

The elevation, area, and volume relationships used were the area-capacity curves developed by the Aerospace Corporation (1971) and used by the USBR in its Salton Sea Operation Study (USBR, 1981b). Surface area was computed using the following equation:

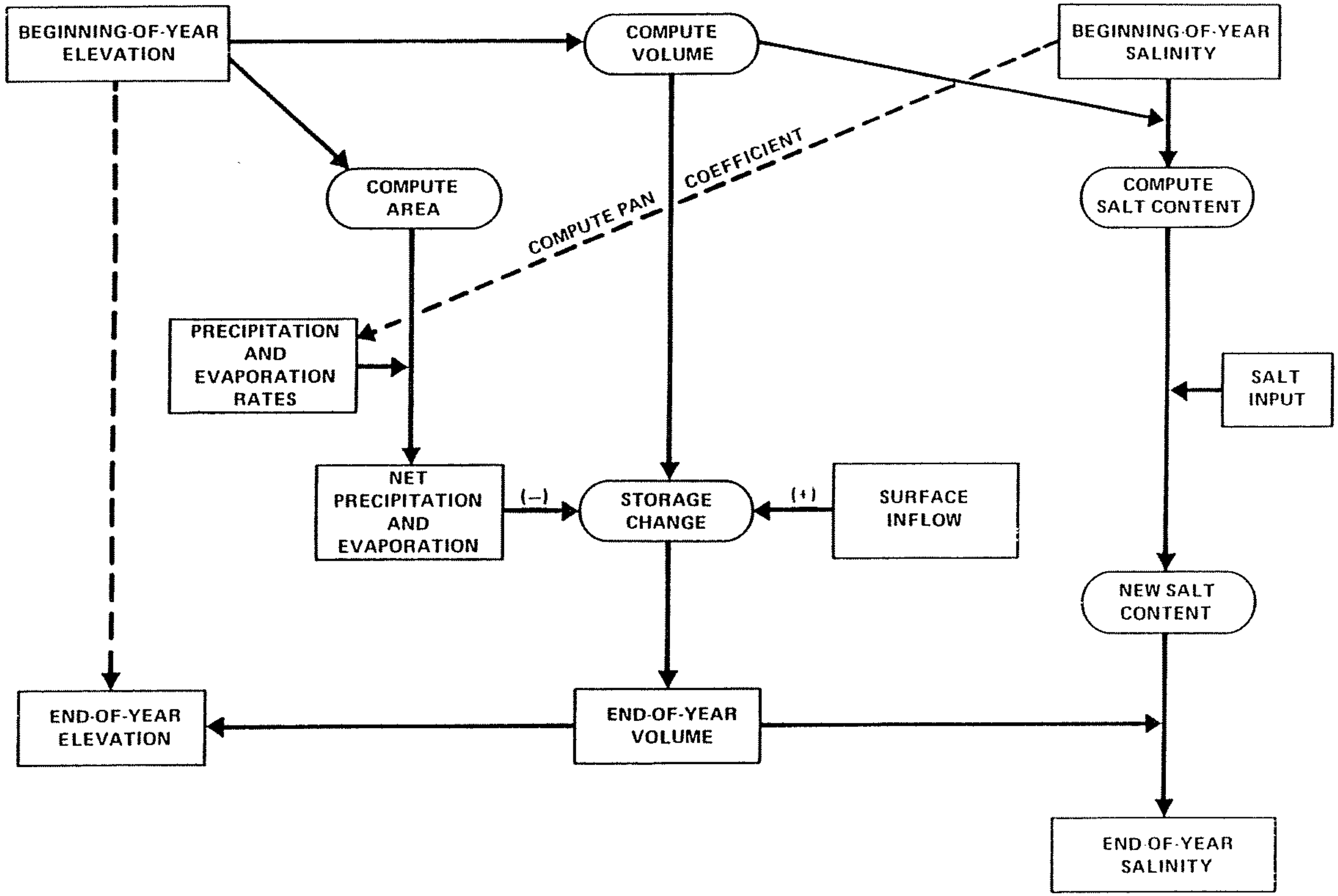


Figure E.5-1 - Flow Chart of Salton Sea Model
(Parsons, 1986)

$$A = 221{,}800\ e^{M(E + 235)}$$

where,

A = area (acres)
E = elevation (ft)
M = 1 (if $E = -235$ ft)
= 0.012242 (if $E > -235$ ft)
= 0.023816 (if $E < -235$ ft)

The volume of the Salton Sea was calculated from the following equation:

$$V = 5{,}360{,}100 + [(A - 221{,}800)/M]$$

where,

V = volume (AF)

These formulas were used to calculate the year-end elevation based on the year-end volume.

E.5.1.2 EVAPORATION

Evaporation was calculated (as described in Chapter E.3) for the historical period using a pan coefficient of 0.69. This is the value developed by the USGS (Hely et al., 1966) and is well documented and used. This coefficient relates actual evaporation from the Salton Sea to the measured pan evaporation data. However, as the salinity of the sea increases, it is anticipated that the evaporation rate will decrease. This decrease will be reflected in a reduction in the pan coefficient. The following relationship (USBR, 1981b) was used to identify pan coefficients for salinity greater than 56,200 mg/L:

$$P = 0.7136 - (0.3792 \times 10^{-6})(S) - (0.7329 \times 10^{-12})(S^2)$$

where,

P = pan coefficient
S = salinity in mg/L

E.5.1.3 MODEL EVALUATION

The model was evaluated using the historical water budget presented in Chapter 4. The total period between 1949-1984 was used. The average inflow, rainfall, and evaporation rates for this period were used to compare the historical change in elevation with that predicted by the model using the year-end elevation in 1949 as the starting point. The average annual inflow was 1,368,000 AF/year. The average rainfall was 2.33 in. (0.1943 ft based on 44,500 AF/year over 229,100 acres). The average evaporation was 5.79 ft (1,326,000 AF/year using a pan coefficient of 0.69). This evaluation compared the elevation determined by long-term averages to the actual change in elevation.

The results of this comparison are shown in Figure E.5-2. The modeled elevation data show a good fit to the historical data with a correlation coefficient of 0.95. Because the model is based on long-term averages for inflow and evaporation, the model indicates long-term trends in the elevation of the sea. Short-term fluctuations in elevation occur as a result of variations in storm runoff, agricultural return flows, and other runoff such as inflow from Mexico and the Coachella Valley. These fluctuations are not shown in the modeled elevations.

The model was calibrated for salinity by comparing the historic salinity of the Salton Sea with the salinity determined by various salt loading rates. Because salinity is dependent on both the volume (elevation) and salt loading, the volume was calculated from historic elevation rather than modeled elevation for calibration purposes Thus, the accuracy of the salinity calculations was separated from that of the elevation calculations. The model was calibrated using the salt loading values discussed in subsection E.3.3 and the observed salinity in 1951 as the starting point. The average value of 4.27 million tons/year was used for the first calibration presented in Figure E.5-3. This figure shows a reasonable correspondence to the historical salinity with a correlation coefficient of 0.89. In Figure E.5-4, the calibration was repeated using a more detailed breakdown of the historical salt loading:

Range	Million tons/year
1950-1963	3.67
1964-1972	4.44
1973-1984	5.00

Figure E.5-4 shows a closer correspondence to the historical salinity with a correlation coefficient of 0.91. The recent period (1970-1984) appears to have a very close correspondence with the historical record. It should be noted that the historical salinity data is based on a few stations sampled by the IID. Because these stations may not be representative of the average salinity of the sea and because the salt loading rates are based on measurements other than at the IID's stations, the observed correlation is considered very good. These calibration curves suggest two conclusions:

(1) The area-capacity curves for the Salton Sea are reasonably accurate.

(2) The salt-loading rates are fairly close to the actual historical rates.

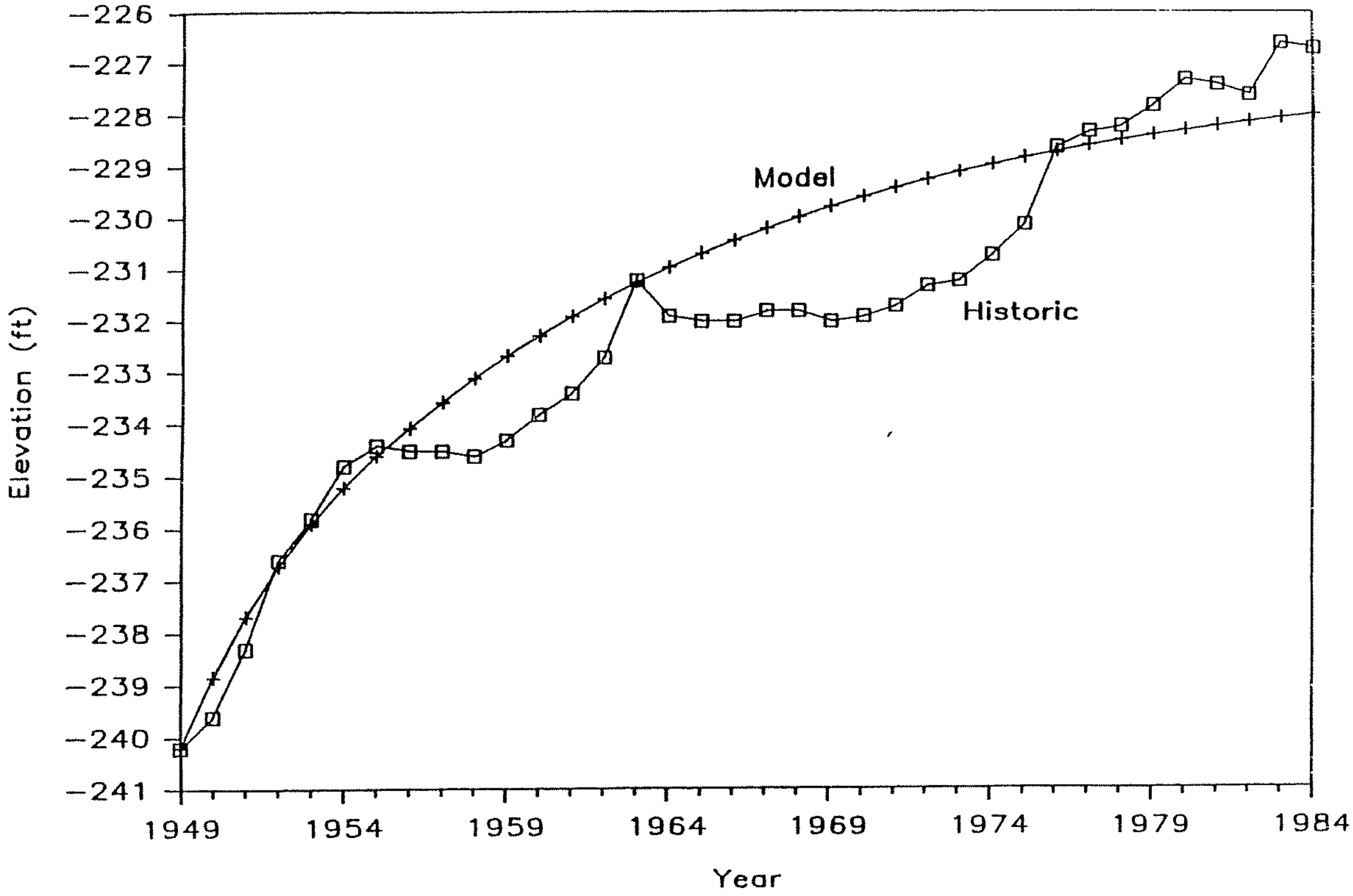


Figure E.5-2 - Historic Salton Sea: Model Evaluation
(Parsons, 1986)

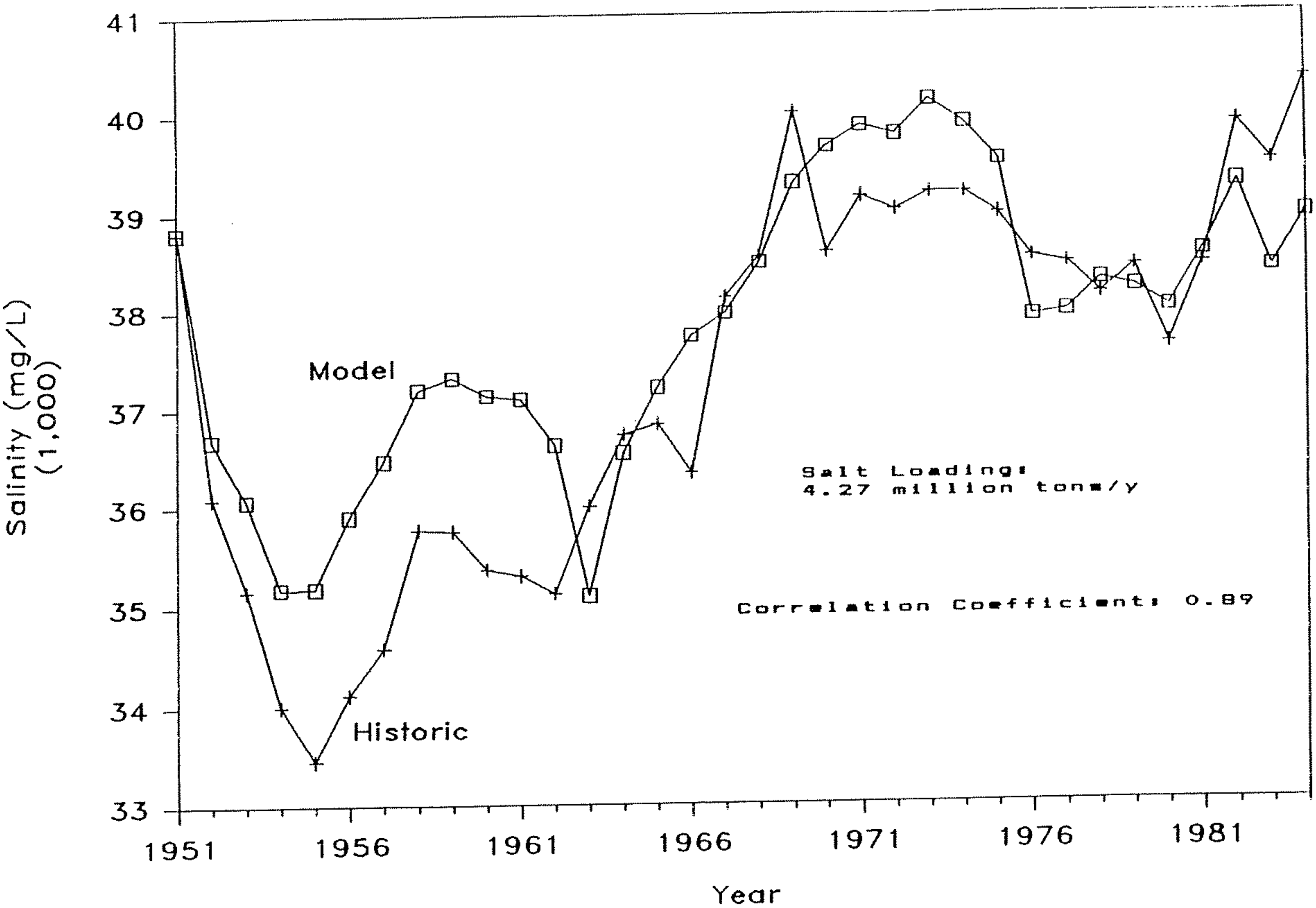


Figure E.5-3 - Salinity Calibration 1
(Parsons, 1986)

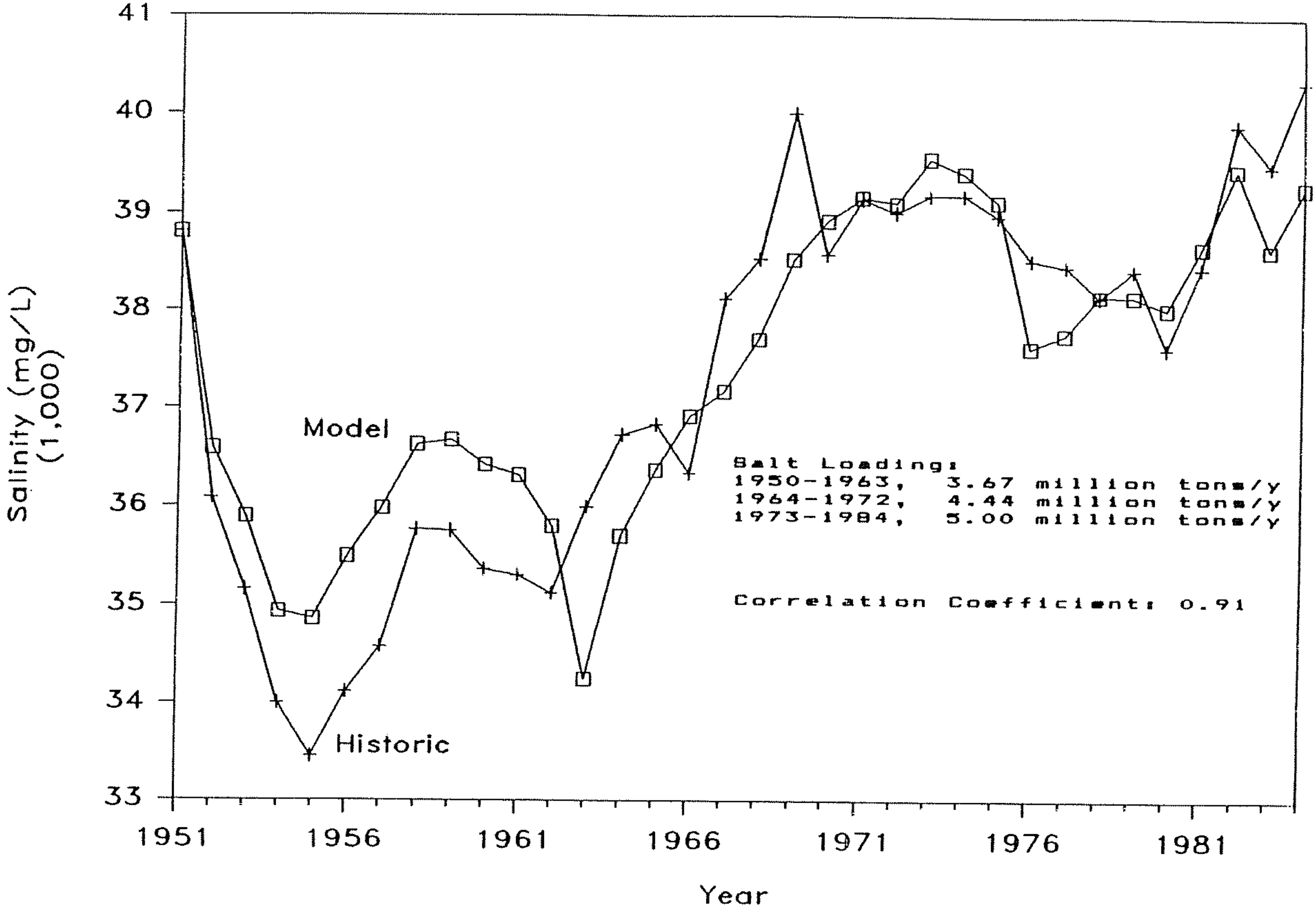


Figure E.5-4 - Salinity Calibration 2
(Parsons, 1986)

Therefore, the model is reasonably justified as a means of projecting Salton Sea salinities. It should be noted though that the actual future salinities may vary considerably from the modeled salinities because both inflows and salt loading are likely to vary from the average values used in this study.

The effect of changes in the pan evaporation coefficient could not be assessed for this calibration. The historical salinity of the sea is considerably below 56,200 mg/L, the concentration at which increasing salinity is expected to have a negative effect on the evaporation rate. The pan coefficient for the historical period was thus constant at 0.69.

E.5.2 PROJECTIONS OF FUTURE ELEVATIONS AND SALINITY

E.5.2.1 BASELINE HYDROLOGIC CONDITIONS

The future of the Salton Sea is dependent on future inflow and the salinity of the incoming water. As long as an inflow is maintained, there will be a Salton Sea. However, the volume of the sea may change dramatically, affecting both the level of the sea and its salinity. In developing projections of the elevation and salinity of the sea, the following assumptions were made on the basis of observations of the historical inflow to the Salton Sea:

(1) The contribution from the IID has been reduced in recent years to its present level of about 810,000 AF/year (1985 baseline, 812,680 AF/year in 1986). This was the average for the period 1982-1984 and was assumed to be the baseline contribution from the IID. However, it should be noted that this value may change significantly as changes are made in agricultural subsidy programs and other economic effects. The IID's contribution was increased to 877,000 AF/year in year 2010, based on projections of the IID's water use (Parsons, 1985a).

(2) The historical contribution from the Coachella Valley has held fairly stable at about 208,000 AF/year. This was the average for the period 1982-1984 and was assumed to remain constant. This average was therefore used to model future inflow from the Coachella Valley.

(3) Although the historical inflow from storm runoff and other sources is variable, the long-term average for the years 1950-1984 was assumed to represent a reasonable quantity for this category (95,000 AF/year).

(4) Long-term average direct rainfall and evaporation were used (0.1943 ft/year and 5.789 ft/year, respectively). Evaporation is equivalent to 8,390 ft/year with a pan coefficient of 0.69.

(5) The inflow from Mexico via the New and Alamo Rivers has increased dramatically in recent years to about 250,000 AF/year. This is likely a result of an increased diversion of Colorado River water and use in Mexico for irrigation. This number was thus used as a starting point; however, it was also assumed that excess Colorado River water would not be as prevalent in the future. The flow from Mexico was thus decreased over a 5-year period beginning in 1987 to a sustained flow of 160,000 AF/year (Case 1) and 200,000 AF/year (Case 2). These two cases were used to indicate the uncertainty surrounding this component of inflow to the Salton Sea.

(6) The historical salt loading has been estimated in several reports. For this analysis, the worst case of approximately 5 million tons/year was used, based on the USBR estimate for the period 1963-1980 (USBR, 1981b) and the 1973-1984 period. Although the Colorado River's salinity is expected to increase, the salt loading of 5 million tons/year was maintained constant for future projections of salinity in the Salton Sea. It is recognized that water conservation will reduce the salt inflow to Imperial Valley based on the future salinity of the conserved water. However, there is uncertainty surrounding the contribution of salt to the sea from leach water (i.e., soil water). Based on this interaction, it is not certain that reducing the salt inflow to the IID would result in reduction in salt outflow to the Salton Sea. Although this reduction would be expected over the long term, the period 1985-2010 is relatively short term. The present lack of data on the soil water and salinity interaction makes this difficult to assess. For these reasons, the salt loading was maintained constant while recognizing the potential for significant changes in the future.

A summary of the baseline conditions used for this analysis is shown in Table E.5-1. Subsection E.5.2.2 presents results for a projected scenario of reduction in flows to the sea, based on a preliminary schedule for implementation of water conservation measures.

Table E.5-1 - Summary of Baseline Hydrologic Conditions

	Inflow (1,000 AF/year)				Direct	
	IID[a]	Coachella Valley	Other	Mexico	Rain (ft/year)	Evaporation (ft/year)
Case 1[b]	810	208	95	160[d]	0.1943	5.789[e]
Case 2[c]	810	208	95	200[d]	0.1943	5.789[e]

[a] IID baseline contribution for 1985; increases to 877,000 AF/year in year 2010.
[b] Sustained Mexico flow of 160,000 AF/year.
[c] Sustained Mexico flow of 200,000 AF/year.
[d] Initially, 250,000 AF/year; decreases to this value after 5 years beginning in 1987.
[e] Equivalent to 8.390 ft/year with a pan coefficient of 0.69.
Source: Parsons, 1986.

E.5.2.2 PROJECTED FUTURE CONSERVATION SCENARIO

This subsection estimates a most likely pattern of reduced flows to the Salton Sea. For this purpose, the estimates of conservable water and the schedule for implementation were taken from the Water Requirements and Availability Study (Parsons, 1985a). Although the final selection of water conservation measures has not been made, this represents the best estimate of projected water conservation by the IID. Although this study focuses on the effects of the IID's Water Conservation Program, it is recognized that other variables will enter into the equation. For example, impacts of geothermal development may affect the water and salt balance. However, because of the present requirement to reinject 80% of geothermal water, this effect is expected to be minor. Other uncertainties include storm runoff and patterns of agricultural water use. The effects of geothermal and other industrial development were assumed to be negligible because they contribute minor fractions to the Salton Sea.

Table E.5-2 shows the estimates for quantity of water conserved and the potential for reduction in flow to the Salton Sea. Of a total estimate of 358,000 AF/year of potentially conservable water, most (or 307,000 AF/year) will be reduced from the flow to the Salton Sea.

The only conservation measure that will probably not lower the flow to the Salton Sea is the lining of the All-American Canal between Pilot Knob and Drop No. 1. Seepage from this canal contributes to wetlands or localized groundwater. However, this seepage most likely does not contribute to flow through the irrigated area of the Imperial Valley.

Seepage from the remaining canals is assumed to flow through the irrigated area and, ultimately, into the drainage system to the Salton Sea. Although some seepage is lost to evaporation or evapotranspiration by phreatophytes, for purposes of the worst-case analysis this element is assumed to be relatively minor. Studies have indicated that, essentially, no net change in groundwater storage occurs within the irrigated portion of the valley. For this reason, all water conserved by canal lining (other than the All-American Canal) is assumed to be removed from the inflow to the Salton Sea. The sensitivity analysis given later considers this factor.

Most other conservation techniques result in less operational discharge at the end of the canal system. Thus, the reduced discharge directly lowers the flow to the Salton Sea via the drainage system. Land-leveling and tailwater recovery systems reduce tailwater flow and, thus, reduced the flow into the drainage system. Desalination lowers the salinity of the irrigation water which, in turn, reduces the soil leaching requirements. Thus, less water is delivered to the farm and less water flows into the drainage system. This assumes all leach water ultimately reaches the drainage to the Salton Sea.

It was also assumed that all conservation measures in the miscellaneous category result in a 1:1 reduction in flow to the Salton Sea. The flow of water through the IID and the quantities of water lost is shown schematically in Figure E.5-5. An implementation schedule was used to project the effect of water conservation on the Salton Sea on a yearly basis. The basic schedule presented in the Water Requirements and Availability Study (p. 13-7) was used to estimate the reduction in flows to the sea. This schedule is preliminary but was the best estimate of implementation available. The estimated schedule showing reduced flows to the Salton Sea is shown in Table E.5-3. The only difference between this schedule and that showing total water conserved is the absence of a contribution from the All-American Canal seepage. This schedule was then used as the most probable scenario for modeling the future elevation and salinity of the Salton Sea as described in the following subsections. Again, two different flows (Case 1 and Case 2) were estimated for the contribution from Mexico.

As discussed above, the baseline inflow to the Salton Sea from the IID is 810,000 AF/year; however, the water demand or requirements in Imperial Valley are expected to change. Future water requirements depend on many uncertain factors such as crop patterns, acres in production, industrial growth, and population.

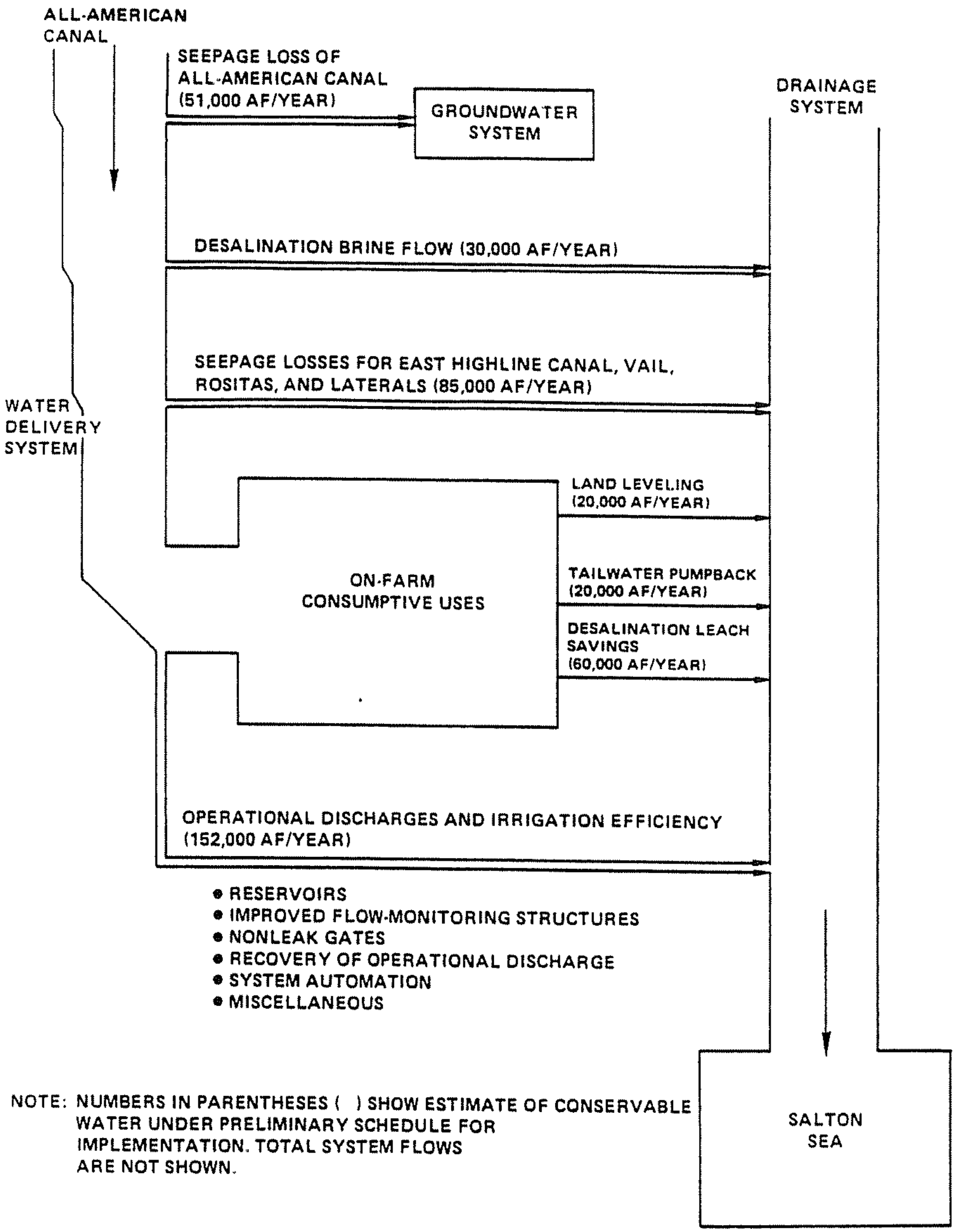


Figure E.5-5 - Water Conservation Opportunities (schematic) (Parsons, 1986)

Table E.5-3 - Estimated Schedule of Conservation-Induced Reduction in Flows to the Salton Sea (1,000 AF/year)

Source	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Canal Lining												
East Highline Canal	-	-	-	-	10	20	30	40	46	46	46	46
Vail Canal	-	1	2	2	2	2	2	2	2	2	2	2
Rositas Canal	1	2	2	2	2	2	2	2	2	2	2	2
Laterals	3	7	10	14	17	21	24	28	31	35	35	35
Reservoirs	4	8	12	16	20	24	28	32	35	35	35	35
Improved flow-monitoring structures	4	9	13	18	22	27	31	36	36	36	36	36
Nonleak gates	3	6	9	14	14	14	14	14	14	14	14	14
Recovery of operational discharges	-	-	3	6	9	12	15	18	21	24	27	30
System automation	3	6	9	12	15	18	21	24	27	27	27	27
Land leveling	2	4	6	8	10	12	14	16	18	20	20	20
On-farm tailwater recovery	2	4	6	8	10	12	14	16	18	20	20	20
Desalination plant	-	-	-	-	-	-	-	-	-	-	-	30
Miscellaneous	-	1	2	3	4	5	6	7	8	9	10	10
Total reduction in flow per year	22	48	74	103	135	169	201	235	258	270	274	307

Source: Parsons, 1985a (p. 13-7). Numbers are adjusted to show only conserved water, which lowers the flow to the Salton Sea.

Virtually all uses contributed to the flow to the Salton Sea. The best estimate for future water requirements was taken from the Water Requirements and Availability Study (Chapter 8) (Parsons, 1985a), which projected an increase in the baseline water requirement from 2.77 million AF in 1985 to 3.00 million AF in year 2010, an increase of 8.3%. To project future elevations and salinity of the Salton Sea, it was assumed that a corresponding change in outflow would occur. Thus, the inflow to the Salton sea was increased from 810,000 AF/year in 1985 to 877,000 AF/year in year 2010. This was used as the best estimate, however, recognizing that future water requirements may actually be considerably higher or lower. Parsons (1985a) estimated a minimum year 2010 requirement of 2.70 million AF and a maximum requirement of 3.50 million AF, based on currently known economic conditions and growth projections.

The baseline TDS on January 1, 1986, used for this analysis was 39,600 mg/L. This value was determined from the Salton Sea sampling conducted January 21-22, 1986 (39,300 mg/L), and adjusted for elevation and slight change in salt loading. The salt loading rate used to calculate the salinity of the Salton Sea was 5.0 million tons/year and was maintained at this constant value for all future inflow. This assumption was made because:

(1) 5 million tons/year is approximately equal to the historical salt loading in recent years (Section E.4).

(2) Although water conservation will result in lower salt, based on the salinity of the conserved water, it was determined that this was slightly greater than the increase in salt loading that is expected to occur because of the rising salinity of the Colorado River.

(3) Uncertainty concerning salinity of the leach water.

A. <u>Case 1: Mexico Inflow Stabilized at 160,000 AF/year</u>

The results of the baseline projection under Case 1 are shown in Tables E.5-4 and E.5-5. The projected elevation and salinity in year 2010 is very similar to that shown in the Water Requirements and Availability Study (Parsons, 1985a, Table 3-21). Elevations are slightly higher in Table E.5-4, however, because of lower evaporation resulting from increasing salinity. The salinity values shown for year 2010 is thus slightly lower because of the greater dilution from inflowing water. However, this effect is minor because the salinity is only slightly greater than 56,200 mg/L, the point at which salinity is expected to begin to decrease evaporation rates.

Table E.5-5 shows the projections of elevation and salinity for the projected future conservation scenario under Case 1. In comparison with the baseline results shown in Table E.5-4, the elevation is considerably lower (-241 ft vs. -229 ft) and the salinity much higher (93,500 mg/L vs. 58,000 mg/L) in year 2010.

Table E.5-4 - Salton Sea Future Elevations and Salinities
(Case 1: Baseline, No Conservation)

Year	Elev. (ft)	Area (1,000 Ac)	Volume (1,000 AF)	Total Inflow (1,000 AF)	Direct Rain (1,000 AF)	Evapor. (1,000 AF)	Storage Change (1,000 AF)	IID Inflow (1,000 AF)	Mexico Inflow (1,000 AF)	Change Conser. (1,000 AF)	Salinity (mg/l)
1986	-226.85	245.1	7,261	1,366	47.62	1,419	-5.42	812.7	250	0	39,600
1987	-226.87	245.0	7,256	1,350	47.60	1,418	-20.37	815.4	232	0	40,136
1988	-226.96	244.8	7,235	1,335	47.56	1,417	-34.29	818.0	214	0	40,757
1989	-227.10	244.3	7,201	1,320	47.47	1,414	-47.26	820.7	196	0	41,462
1990	-227.29	243.8	7,154	1,304	47.36	1,411	-59.35	823.4	178	0	42,250
1991	-227.53	243.0	7,094	1,289	47.22	1,407	-70.60	826.1	160	0	43,122
1992	-227.82	242.2	7,024	1,292	47.05	1,402	-63.09	828.8	160	0	44,078
1993	-228.08	241.4	6,961	1,294	46.90	1,397	-56.09	831.4	160	0	45,006
1994	-228.32	240.7	6,905	1,297	46.77	1,393	-49.56	834.1	160	0	45,904
1995	-228.52	240.1	6,855	1,300	46.65	1,390	-43.49	836.8	160	0	46,772
1996	-228.71	239.6	6,812	1,302	46.55	1,387	-37.83	839.5	160	0	47,611
1997	-228.86	239.1	6,774	1,305	46.46	1,384	-32.56	842.2	160	0	48,420
1998	-229.00	238.7	6,741	1,308	46.38	1,382	-27.65	844.8	160	0	49,199
1999	-229.12	238.4	6,713	1,311	46.31	1,380	-23.08	847.5	160	0	49,949
2000	-229.21	238.1	6,690	1,313	46.26	1,378	-18.82	850.2	160	0	50,671
2001	-229.29	237.9	6,672	1,316	46.22	1,377	-14.85	852.9	160	0	51,365
2002	-229.35	237.7	6,657	1,319	46.18	1,376	-11.15	855.6	160	0	52,032
2003	-229.40	237.5	6,646	1,321	46.15	1,375	-7.71	858.2	160	0	52,672
2004	-229.43	237.4	6,638	1,324	46.14	1,375	-4.50	860.9	160	0	53,287
2005	-229.45	237.4	6,633	1,327	46.12	1,374	-1.51	863.6	160	0	53,878
2006	-229.46	237.4	6,632	1,329	46.12	1,374	1.27	866.3	160	0	54,444
2007	-229.45	237.4	6,633	1,332	46.12	1,374	3.87	869.0	160	0	54,988
2008	-229.44	237.4	6,637	1,335	46.13	1,374	6.28	871.6	160	0	55,510
2009	-229.41	237.5	6,643	1,337	46.15	1,375	8.53	874.3	160	0	56,011
2010	-229.37	237.6	6,652	1,340	46.17	1,375	10.95	877.0	160	0	56,492

Notes:
Elevation and salinity data are shown at the beginning of the year.
Baseline Inflow = 812,680 AF (IID), 208,000 AF (Coachella), 95,000 AF (other); Mexico inflow is 250,000 AF initially and decreases to 160,000 AF over a 5-year period beginning in 1987. IID inflow increases to 877,000 AF/year in 2010 and remains constant thereafter.
Direct Rain = 0.1943 ft/year.
Evaporation = 5.789 ft/year at a pan coefficient of 0.69.
Source: Parsons, 1986.

Table E.5-5 - Salton Sea Future Elevations and Salinities
(Case 1: Projected Future Conservation Scenario)

Year	Elev. (ft)	Area (1,000 Ac)	Volume (1,000 AF)	Total Inflow (1,000 AF)	Direct Rain (1,000 AF)	Evapor. (1,000 AF)	Storage Change (1,000 AF)	IID Inflow (1,000 AF)	Mexico Inflow (1,000 AF)	Change Conser. (1,000 AF)	Salinity (mg/l)
1986	-226.85	245.1	7,261	1,366	47.62	1,419	-5.42	812.7	250	0	39,600
1987	-226.87	245.0	7,256	1,328	47.60	1,418	-42.37	815.4	232	-22	40,136
1988	-227.05	244.5	7,213	1,287	47.50	1,415	-80.79	818.0	214	-48	40,882
1989	-227.38	243.5	7,132	1,246	47.31	1,410	-116.57	820.7	196	-74	41,860
1990	-227.86	242.1	7,016	1,201	47.03	1,401	-152.91	823.4	178	-103	43,080
1991	-228.49	240.2	6,863	1,154	46.67	1,391	-189.76	826.1	160	-135	44,575
1992	-229.28	237.9	6,673	1,123	46.22	1,377	-208.08	828.8	160	-169	46,394
1993	-230.16	235.3	6,465	1,093	45.72	1,362	-223.15	831.4	160	-201	48,456
1994	-231.12	232.6	6,242	1,062	45.19	1,346	-239.18	834.1	160	-235	50,777
1995	-232.15	229.7	6,003	1,042	44.62	1,330	-243.12	836.8	160	-258	53,413
1996	-233.22	226.7	5,760	1,032	44.05	1,312	-235.65	839.5	160	-270	56,305
1997	-234.26	223.8	5,524	1,031	43.49	1,293	-218.16	842.2	160	-274	59,373
1998	-235.24	220.5	5,306	1,001	42.85	1,271	-227.36	844.8	160	-307	62,506
1999	-236.29	215.1	5,079	1,004	41.79	1,237	-191.51	847.5	160	-307	66,028
2000	-237.19	210.5	4,887	1,006	40.91	1,208	-160.67	850.2	160	-307	69,368
2001	-237.96	206.7	4,726	1,009	40.16	1,183	-134.15	852.9	160	-307	72,504
2002	-238.61	203.5	4,592	1,012	39.54	1,162	-111.38	855.6	160	-307	75,423
2003	-239.16	200.9	4,481	1,014	39.03	1,145	-91.83	858.2	160	-307	78,118
2004	-239.62	198.7	4,389	1,017	38.60	1,131	-75.06	860.9	160	-307	80,590
2005	-240.00	196.9	4,314	1,020	38.25	1,119	-60.70	863.6	160	-307	82,845
2006	-240.31	195.4	4,253	1,022	37.97	1,109	-48.40	866.3	160	-307	84,891
2007	-240.56	194.3	4,205	1,025	37.75	1,101	-37.88	869.0	160	-307	86,743
2008	-240.76	193.4	4,167	1,028	37.57	1,094	-28.89	871.6	160	-307	88,414
2009	-240.91	192.7	4,138	1,030	37.44	1,089	-21.21	874.3	160	-307	89,919
2010	-241.02	192.2	4,117	1,033	37.34	1,085	-14.65	877.0	160	-307	91,276

Notes:
Elevation and salinity data are shown at the beginning of the year.
Baseline Inflow = 812,680 AF (IID), 208,000 AF (Coachella), 95,000 AF (other); Mexico inflow is 250,000 AF initially and decreases to 160,000 AF over a 5-year period beginning in 1987. IID inflow increases to 877,000 AF/year in 2010 and remains constant thereafter.
Direct Rain = 0.1943 ft/year.
Evaporation = 5.789 ft/year at a pan coefficient of 0.69.
Source: Parsons, 1986.

This salinity is partially a result of continuing salt loading to the sea; however, the high salinity is primarily a result of the lower elevation and hence smaller volume in which the salts are distributed. These results are shown graphically in Figure E.5-6. This figure also shows an example of annual fluctuation around the long-term trend line that may occur, based on historic records.

B. Case 2: Mexico Inflow Stabilized at 200,000 AF/year

The results of the Case 2 projections shown in Tables E.5-6 and E.5-7 are very similar to the results shown above for Case 1. As a result of higher inflows from Mexico, however, the elevations shown for Case 2 are slightly higher and salinities are slightly lower. But the salinity under the projected future conservation scenario is still a tremendous increase over the baseline conditions in the year 2010 (87,600 mg/L vs. 54,300 mg/L). The increase in salinity is partly a result of continuing salt loading to the sea; however, the large salinity increase is primarily caused by the large drop in elevation and volume of the sea. The projected salinity and elevation are shown in Figure E.5-7.

C. Sensitivity Analysis

The projections of the Salton Sea's elevation and salinity incorporated several simplifying assumptions including:

(1) Assuming a salt loading rate of 5 million tons/year.

(2) Assuming for worst-case purposes that 100% of canal seepage within the central area of IID contributes to the flow to the Salton Sea.

The first assumption may be erroneous because of projected increases in Colorado River salinity. The second assumption ignores the contribution of canal seepage to direct evaporation or evapotranspiration by phreatophytes. A sensitivity analysis was conducted to determine the potential effect of these parameters on projections of elevation and salinity. The results are presented in Table E.5-8.

Salt loading was increased to 6 million tons/year. As shown in Table E.5-8, this increase of 1 million tons/year results in less than a 5% increase in salinity by the year 2010. For example under Case 2: with conservation, the salinity has increased from 85,500 mg/L to 89,500 mg/L. The salinity is, thus, fairly insensitive to errors in the salt loading rate.

In the second comparison, the maximum reduction in conservation flows was changed from 307,000 AF/year to 281,000 AF/year (i.e., higher inflows were maintained to the Salton Sea). This change resulted in a decrease of about 4% in the year 2010 salinity. For example, the Case 2 (with conservation) scenario resulted in

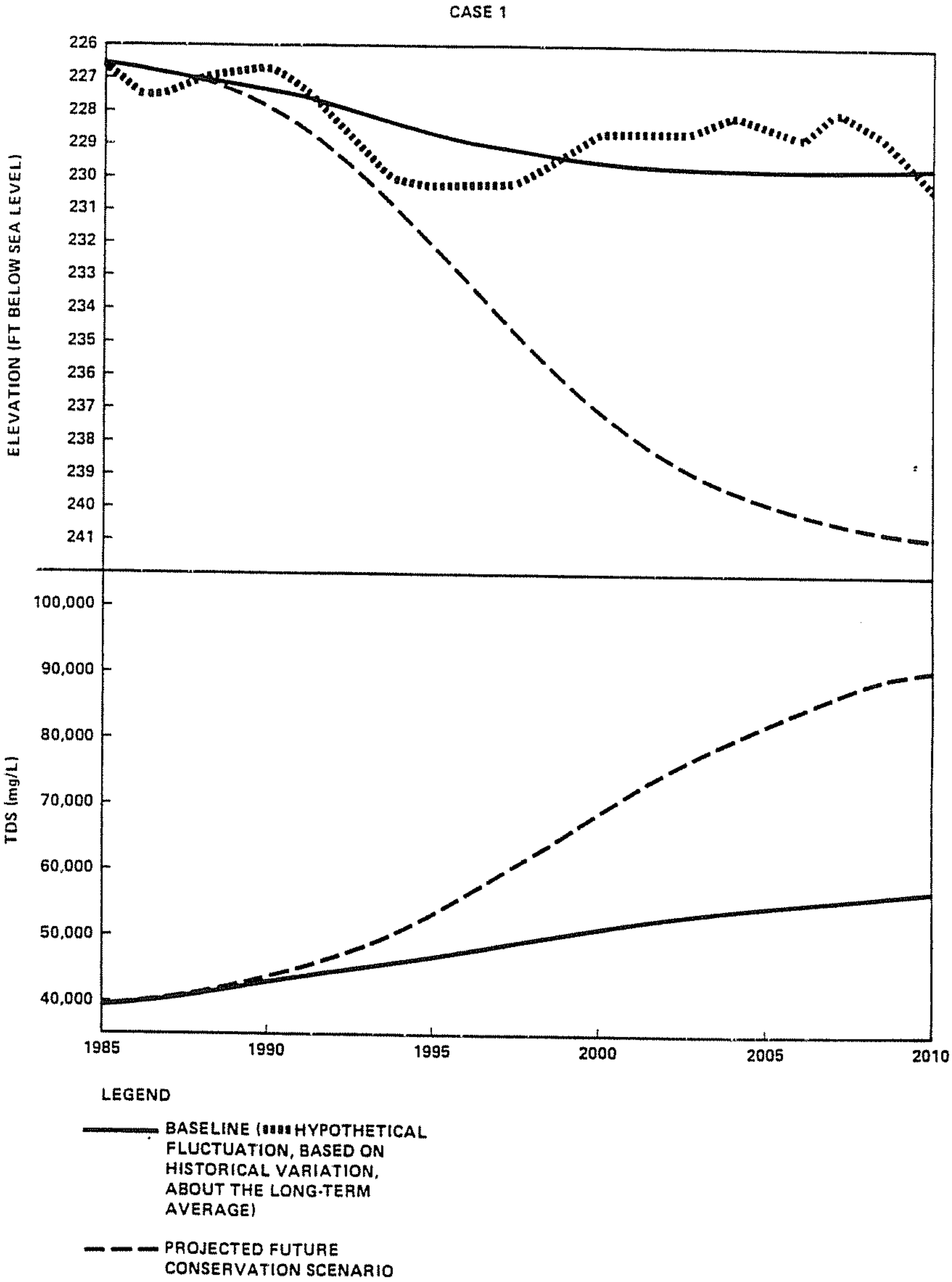


Figure E.5-6 - Case 1: Projected Elevation and Salinity (Parsons, 1986)

Table E.5-6 - Salton Sea Future Elevations and Salinities
(Case 2: Baseline, No Conservation)

Year	Elev. (ft)	Area (1,000 Ac)	Volume (1,000 AF)	Total Inflow (1,000 AF)	Direct Rain (1,000 AF)	Evapor. (1,000 AF)	Storage Change (1,000 AF)	IID Inflow (1,000 AF)	Mexico Inflow (1,000 AF)	Change Conser. (1,000 AF)	Salinity (mg/l)
1986	-226.85	245.1	7,261	1,366	47.62	1,419	-5.42	812.7	250	0	39,600
1987	-226.87	245.0	7,256	1,358	47.60	1,418	-12.37	815.4	240	0	40,136
1988	-226.92	244.9	7,243	1,351	47.58	1,417	-18.84	818.0	230	0	40,712
1989	-227.00	244.6	7,224	1,344	47.53	1,416	-24.87	820.7	220	0	41,327
1990	-227.10	244.3	7,200	1,336	47.47	1,414	-30.49	823.4	210	0	41,981
1991	-227.23	243.9	7,169	1,329	47.40	1,412	-35.72	826.1	200	0	42,672
1992	-227.37	243.5	7,133	1,332	47.31	1,410	-30.59	828.8	200	0	43,401
1993	-227.50	243.1	7,103	1,334	47.24	1,407	-25.82	831.4	200	0	44,106
1994	-227.60	242.8	7,077	1,337	47.18	1,406	-21.37	834.1	200	0	44,786
1995	-227.69	242.6	7,056	1,340	47.13	1,404	-17.23	836.8	200	0	45,443
1996	-227.76	242.3	7,038	1,342	47.09	1,403	-13.37	839.5	200	0	46,077
1997	-227.82	242.2	7,025	1,345	47.06	1,402	-9.77	842.2	200	0	46,688
1998	-227.86	242.1	7,015	1,348	47.03	1,401	-6.42	844.8	200	0	47,277
1999	-227.89	242.0	7,009	1,351	47.02	1,401	-3.30	847.5	200	0	47,845
2000	-227.90	241.9	7,005	1,353	47.01	1,401	-0.40	850.2	200	0	48,392
2001	-227.90	241.9	7,005	1,356	47.01	1,401	2.31	852.9	200	0	48,919
2002	-227.89	242.0	7,007	1,359	47.01	1,401	4.83	855.6	200	0	49,428
2003	-227.87	242.0	7,012	1,361	47.03	1,401	7.18	858.2	200	0	49,918
2004	-227.84	242.1	7,019	1,364	47.04	1,402	9.37	860.9	200	0	50,391
2005	-227.80	242.2	7,029	1,367	47.06	1,402	11.41	863.6	200	0	50,847
2006	-227.76	242.4	7,040	1,369	47.09	1,403	13.31	866.3	200	0	51,287
2007	-227.70	242.5	7,053	1,372	47.12	1,404	15.08	869.0	200	0	51,711
2008	-227.64	242.7	7,069	1,375	47.16	1,405	16.72	871.6	200	0	52,121
2009	-227.57	242.9	7,085	1,377	47.20	1,406	18.26	874.3	200	0	52,517
2010	-227.50	243.1	7,104	1,380	47.24	1,408	19.69	877.0	200	0	52,899

Notes:
Elevation and salinity data are shown at the beginning of the year.
Baseline Inflow = 812,680 AF (IID), 208,000 AF (Coachella), 95,000 AF (other); Mexico inflow is 250,000 AF initially and decreases to 200,000 AF over a 5-year period beginning in 1987. IID inflow increases to 877,000 AF/year in 2010 and remains constant thereafter.
Direct Rain = 0.1943 ft/year.
Evaporation = 5.789 ft/year at a pan coefficient of 0.69.
Source: Parsons, 1986.

Table E.5-7 - Salton Sea Future Elevations and Salinities
(Case 2: Projected Future Conservation Scenario)

Year	Elev. (ft)	Area (1,000 Ac)	Volume (1,000 AF)	Total Inflow (1,000 AF)	Direct Rain (1,000 AF)	Evapor. (1,000 AF)	Storage Change (1,000 AF)	IID Inflow (1,000 AF)	Mexico Inflow (1,000 AF)	Change Conser. (1,000 AF)	Salinity (mg/l)
1986	-226.85	245.1	7,261	1,366	47.62	1,419	-5.42	812.7	250	0	39,600
1987	-226.87	245.0	7,256	1,336	47.60	1,418	-34.37	815.4	240	-22	40,136
1988	-227.01	244.6	7,221	1,303	47.52	1,416	-65.33	818.0	230	-48	40,836
1989	-227.28	243.8	7,156	1,270	47.37	1,411	-94.18	820.7	220	-74	41,723
1990	-227.67	242.6	7,062	1,233	47.14	1,405	-124.05	823.4	210	-103	42,800
1991	-228.18	241.1	6,938	1,194	46.85	1,396	-154.87	826.1	200	-135	44,095
1992	-228.83	239.2	6,783	1,163	46.48	1,385	-175.59	828.8	200	-169	45,644
1993	-229.56	237.1	6,607	1,133	46.06	1,372	-192.88	831.4	200	-201	47,414
1994	-230.36	234.7	6,414	1,102	45.60	1,359	-210.99	834.1	200	-235	49,412
1995	-231.28	232.1	6,203	1,082	45.10	1,344	-216.86	836.8	200	-258	51,686
1996	-232.22	229.5	5,986	1,072	44.59	1,328	-211.33	839.5	200	-270	54,172
1997	-233.15	226.9	5,775	1,071	44.08	1,313	-197.60	842.2	200	-274	56,791
1998	-234.03	224.5	5,578	1,041	43.61	1,297	-212.06	844.8	200	-307	59,462
1999	-234.98	221.9	5,365	1,044	43.11	1,279	-192.24	847.5	200	-307	62,498
2000	-235.85	217.4	5,174	1,046	42.24	1,250	-161.92	850.2	200	-307	65,519
2001	-236.60	213.5	5,012	1,049	41.49	1,226	-135.37	852.9	200	-307	68,369
2002	-237.24	210.3	4,877	1,052	40.86	1,205	-112.56	855.6	200	-307	71,021
2003	-237.78	207.6	4,764	1,054	40.34	1,188	-92.97	858.2	200	-307	73,470
2004	-238.23	205.4	4,671	1,057	39.91	1,173	-76.16	860.9	200	-307	75,720
2005	-238.60	203.6	4,595	1,060	39.56	1,161	-61.75	863.6	200	-307	77,775
2006	-238.90	202.1	4,533	1,062	39.27	1,151	-49.40	866.3	200	-307	79,645
2007	-239.15	200.9	4,484	1,065	39.04	1,143	-38.83	869.0	200	-307	81,342
2008	-239.34	200.0	4,445	1,068	38.86	1,136	-29.78	871.6	200	-307	82,880
2009	-239.49	199.3	4,415	1,070	38.72	1,131	-22.04	874.3	200	-307	84,272
2010	-239.60	198.8	4,393	1,073	38.62	1,127	-15.42	877.0	200	-307	85,531

Notes:
Elevation and salinity data are shown at the beginning of the year.
Baseline Inflow = 812,680 AF (IID), 208,000 AF (Coachella), 95,000 AF (other); Mexico inflow is 250,000 AF initially and decreases to 200,000 AF over a 5-year period beginning in 1987. IID inflow increases to 877,000 AF/year in 2010 and remains constant thereafter.
Direct Rain = 0.1943 ft/year.
Evaporation = 5.789 ft/year at a pan coefficient of 0.69.
Source: Parsons, 1986.

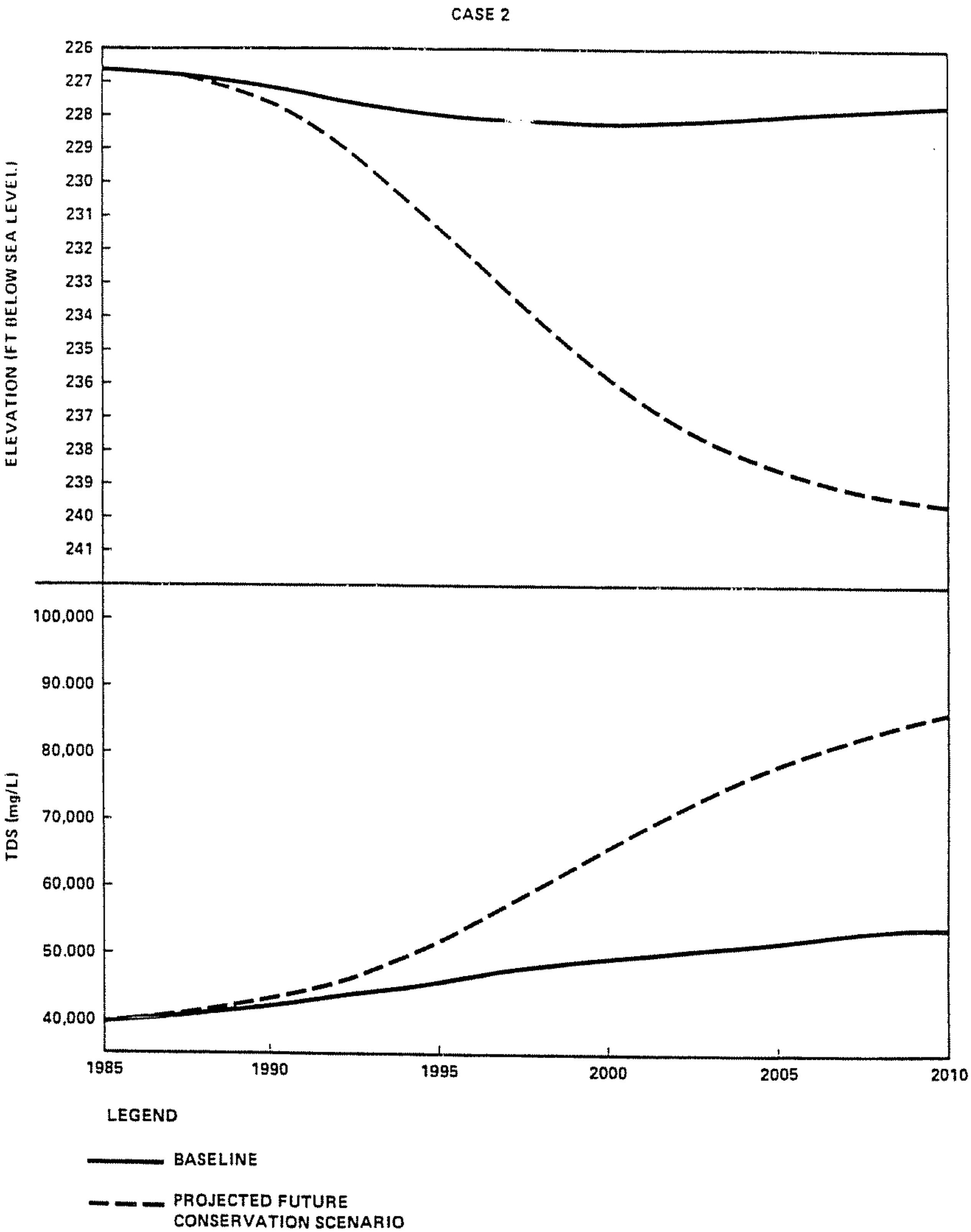


Figure E.5-7 - Case 2: Projected Elevation and Salinity (Parsons, 1986)

Table E.5-8 - Sensitivity Analysis of Salton Sea Modeling Results (year 2010)

	Conservation Reduction in Flow Totals 307,000 AF/year in 1998		Conservation Reduction in Flow Totals 281,000 AF/year in 1998	
	5 million tons/year[a]	6 million tons/year[a]	5 million tons/year[a]	6 million tons/year[a]
Case 1: Baseline (Mexico inflow stabilized at 160,000 AF/year)				
Salinity (mg/L)	56,500	59,100	ND	ND
Elevation (ft)	-229.4	-229.4		
Case 1: With conservation				
Salinity (mg/L)	91,300	95,500	87,600	91,762
Elevation (ft)	-241.0	-241.0	-240.1	-240.1
Case 2: Baseline (Mexico inflow stabilized at 200,000 AF/year)				
Salinity (mg/L)	52,900	55,400	ND	ND
Elevation (ft)	-227.5	-227.5		
Case 2: With conservation				
Salinity (mg/L)	85,500	89,500	82,300	86,136
Elevation (ft)	-239.6	-239.6	-238.3	-238.3

ND = no difference from baseline under reduced flow conditions of 307,000 AF/year.
[a] Salt loading.
Source: Parsons, 1986.

a decrease in the year 2010 salinity from 85,500 mg/L to 82,300 mg/L. Although this is a small change it indicates that a very small change in inflow (less than 3%) can have a relatively large impact on salinity (approximately 4%).

These analyses suggest that the modeling results presented in subsections 5.2.2.A and 5.2.2.B, above, reasonably represent projections of future elevation and salinity. It should be noted, however, that effects such as storm runoff may have dramatic effects on short-term elevation and salinity. The modeling results shown here are likely to be representative of the long-term trend.

D. Summary

Table E.5-9 summarizes the results of modeling discussed in previous subsections. The elevation and salinity in year 2010 are presented, along with the approximate stabilizing elevation. As shown in this table, the elevations have essentially reached stabilization in year 2010, e.g., under the Case 1 projected future scenario, the elevation has decreased to -241 ft in year 2010. In future years, without further reductions in inflow, the elevation of the sea would actually begin to increase. This is a result of the decreasing evaporation rates resulting from increasing salinity. The results of this model are presented to indicate the projected trends in elevation and salinity. For this purpose, long-term averages were used for the hydrologic components. However, it is recognized that great yearly variation will occur in all elements of inflow and evaporation. These results, however, indicate the approximate value of the future elevation and salinity based on a long period of time.

The projected baseline water requirements in year 2010 are based on the analysis presented in Parsons (1985a); however, this analysis is an estimate only. Parsons (1985a) also estimated possible minimum and maximum water requirements. These numbers are approximately 10% lower and 17% higher, respectively, than the baseline water requirements. It would be expected that water use within the IID would have a corresponding effect on the flow to the Salton Sea. This variation or uncertainty in flows would have a significant effect on the salinity of the sea. An increase in water use, for example, would compensate partially for the decreased flow caused by water conservation.

Other important future variables are chemical processes such as crystallization and precipitation. These two processes could remove some salt from the Salton Sea and thus somewhat lower the rate of increase of salinity. In addition, suspended solids loads, although small, could gradually change the area-capacity relationship of the sea to effectively raise the elevation. These two processes have not been considered in this modeling study but should be noted for future evaluations.

Table E.5-9 - Comparison of Projected Future Conservation Scenario with Baseline Inflow: Case 1 vs. Case 2

Conservation Scenario (reduced Salton Sea inflow)	Case 1[a]				Case 2[b]			
	Year 2010		Stabilizing		Year 2010		Stabilizing	
	Elevation (ft)	Salinity (mg/L)	Elevation (ft)	Year[c]	Elevation (ft)	Salinity (mg/L)	Elevation (ft)	Year[c]
Baseline	-229	56,500	-229	2000	-228	52,900	-228	1995
Projected future (peak reduction 307,000 AF/year)	-241	91,300	-241	2010	-241	85,500	-240	2010

[a] Mexico inflow stabilized at 160,000 AF/year.
[b] Mexico inflow stabilized at 200,000 AF/year.
[c] Year of stabilization defined as year in which change in volume is less than 20,000 AF or year in which elevation begins to rise.
Source: Parsons, 1986.

APPENDIX F
WATER QUALITY INVESTIGATION

CONTENTS

APPENDIX F

WATER QUALITY INVESTIGATION

Appendix F summarizes both the available water quality data for the Imperial Valley and the results of a water quality field survey of the Salton Sea conducted on January 21 and 22, 1986.

F.1 SUMMARY OF AVAILABLE WATER QUALITY DATA

An extensive water quality data base exists for the Imperial Irrigation District (IID). Most of this data is readily available from the U.S. Environmental Protection Agency's STORET (storage/retrieval) system through the California State Water Quality Information System. The water quality data in STORET includes data collected by:

(1) U.S. Geological Survey (USGS)
(2) California Regional Water Quality Control Board (CRWQCB)
(3) U. S. Environmental Protection Agency (EPA)
(4) Arizona Department of Health (ADH)
(5) U.S. Fish and Wildlife Service (FWS)

Between 1949 and 1985, these five agencies conducted water quality sampling at 136 different locations within the IID and analyzed over 126,000 samples for 129 different parameters. Although all parameters were not measured at all locations for all years, many of the locations do have substantial, long-term data bases. All of the STORET data for the IID is available either in summary format or by selected parameter and period.

In addition to the STORET data, other supplemental long- and short-term data is available. The IID has been collecting water quality data since 1955, and the Imperial County Health Department has taken monthly bacteriological samples since 1962. Comprehensive short-term studies recently conducted by a number of companies and individuals include those by Setmire (1984), Engineering-Science (1980), and the CRWQCB (1985).

F.1.1 IMPORTANT WATER QUALITY CONSTITUENTS

An analysis of the IID's water quality data was discussed in detail in Chapters 3 and 6 of the Water Requirements and Availability Study prepared for the IID by Parsons Water Resources, Inc. (Parsons, 1985a). Of all water quality parameters measured, salinity is of major importance throughout the area. The use of water for irrigation results in a 300% to 500% increase in salinity within the valley as water flows from the All-American Canal through the valley to the Alamo and New Rivers and into the Salton Sea. Increases in salinity or total dissolved solids (TDS) are a result of salt leaching from the soil by irrigation water, evaporation, contributions from saline groundwater, and application of fertilizer chemicals.

F.1.2 SALTON SEA SALINITY

Historically, there has been a gradual increase in the concentration of dissolved salts in the Salton Sea. This increase has resulted from high evaporation rates and the continual inflow of drainage waters with high salt loads. Because salinity varies inversely with water flow and the level of the sea, decreasing the water flow through the IID will directly impact the Salton Sea, which depends on this water to control the salt balance. Although water conservation will help to stabilize the level of the Salton Sea, it will also contribute to the problem of increasing salinity. The extent to which this salinity increase will be impacted by IID's conservation measures has been calculated, based on existing data. A complete analysis of the Salton Sea salt balance is presented in Appendix E.

One area where water quality data has historically been inadequate is within the Salton Sea. The five IID stations, which represent conditions in the sea, are measured semiannually at the surface for selected boundary locations (Figure E.4-1). These stations may not accurately represent the vertical and horizontal salinity gradient that exists in the Salton Sea, and any calculation based on this limited data base may present an inaccurate picture of existing salinity conditions.

The last comprehensive water quality survey of the Salton Sea was conducted during July 1972 for the Salton Sea Project, California, Federal-State Feasibility Study (USDI, 1974a). Results of that study showed the average salinity concentration in the Salton Sea at that time to be approximately 38,800 mg/L. The elevation of the Salton Sea during the July 1972 field survey was approximately -231.7 ft.

Studies conducted by the California Regional Water Quality Control Board, Colorado River Basin Region, include between one and three offshore stations. However, these stations have not been monitored with any regularity. The Water Quality Control Plan for the Colorado River Basin established the TDS of the Salton Sea as of May 1983 at 38,900 mg/L (CRWQCB, 1984). This concentration was based on one sample collected in the northern half of the Salton Sea, mid-section, near the County line.

A field survey of the Salton Sea was conducted during January 1986 to verify the salinity distribution throughout the sea. The results of this survey are presented in the following section.

F.2 SALTON SEA SURVEY

A field survey in the Salton Sea was conducted on January 21 and 22, 1986, to determine the vertical and horizontal salinity distribution in the Salton Sea and to verify the validity of using shoreline sampling in order to depict overall sea conditions. The survey was conducted during January when the sea was relatively homogeneous. The sea level recorded by the IID for January 20, 1986, was -226.65 ft; field measurements showed very little vertical temperature stratification; and there had been no recorded rainfall since December 11, 1985.

The field survey included vertical water quality profiles of temperature and conductivity at 37 profiling locations throughout the Salton Sea and discrete water samples at 14 selected stations for chemical analyses.

F.2.1 METHODOLOGY

Figure F-1 presents a map of the Salton Sea showing the location of each of the sampling stations. Positioning of each station was accomplished using a Loran C electronic positioning system and known shoreline locations. Profiles were taken with a Martek Mark III water quality monitoring system. Data was taken at approximate 1-ft intervals, printed on paper tape, and recorded on magnetic cassette tape for further analysis. Temperature and conductivity sensors were calibrated before and after the survey, and periodic checks for accuracy were made each day in the field.

Water samples were collected with Van Dorn water samplers at the surface, near the bottom, and at mid-depth (in the deeper locations), and the samples were transported to the laboratory of the Agricultural Technical Service, Inc., in Brawley for analysis. Chemical analyses included total dissolved solids (TDS), total suspended solids (TSS), and a breakdown of the salt components to differentiate major constituents including sodium, chloride, potassium, calcium, magnesium, sulfate, and bicarbonate. Replicate samples were collected for TDS for most surface water samples, and additional duplicate analyses were also run for TDS samples collected on January 21.

F.2.2 SURVEY RESULTS

Field sampling results are summarized in Tables F-1 through F-3. Table F-1 presents the analytical results for all water samples collected on January 21 and 22. The proportion of ions was calculated, based on the sum of the ions determined through the laboratory analyses. The major ions selected for analysis are those that have been historically sampled throughout the Salton Sea and in ocean waters. Because of the unusually high chloride measurement at the Station 1A surface, this station was not used in the ion calculations.

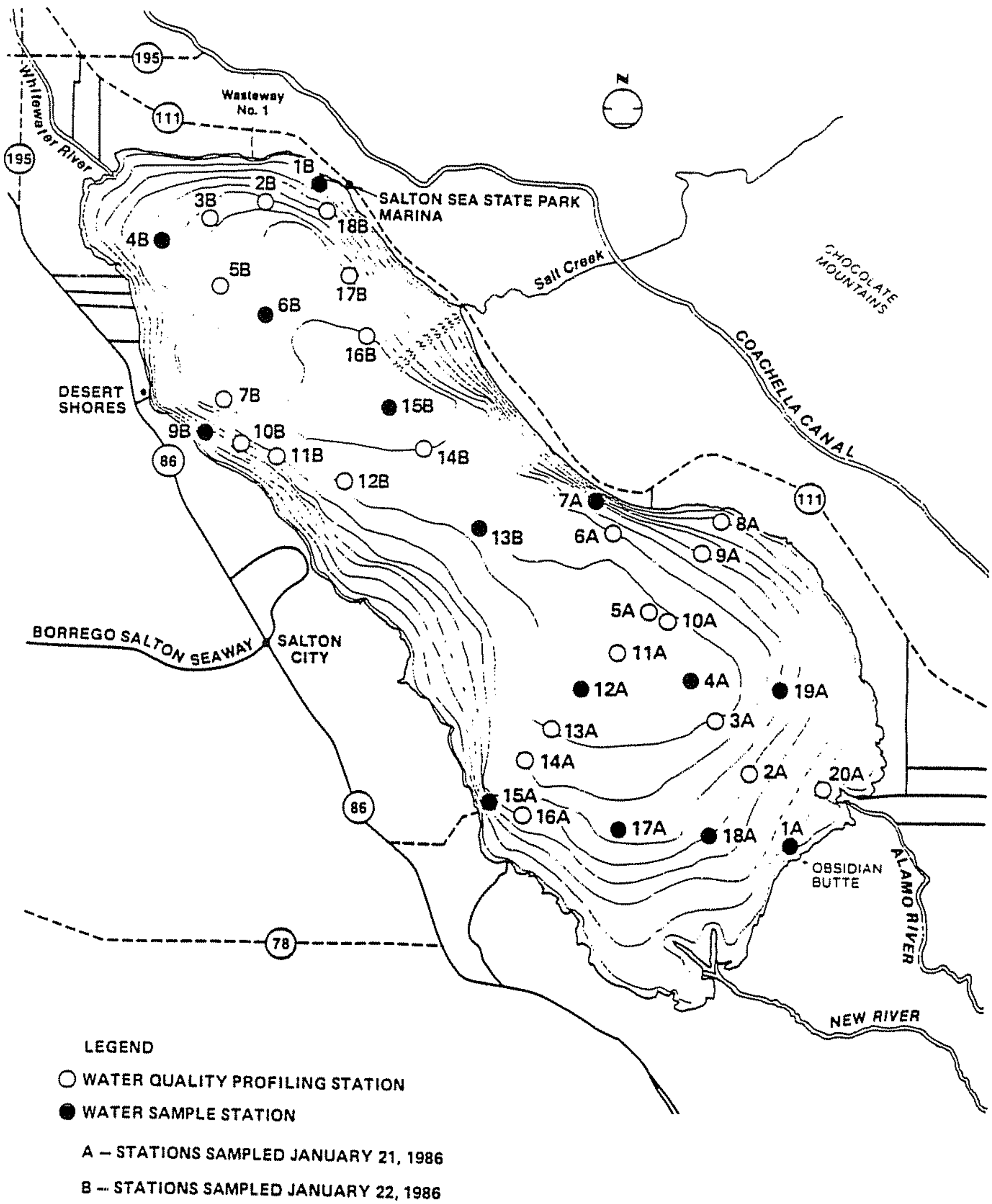


Figure F-1 - Salton Sea Station Location Map
(Parsons, 1986)

Table F-1 - Analysis of Salton Sea Water Samples (Parsons, 1986)

Constituent	1A Surf	1A Bot	4A Surf	4A Mid	4A Bot	7A Surf	7A Mid	7A Bot	12A Surf	12A Mid	12A Bot	15A Surf	15A Bot	17A Surf	17A Mid	17A Bot	18A Surf	19A Surf	
	Station/Depth January 21, 1986																		
LABORATORY DATA																			
Suspended Solids (mg/L)	269	463	117.5	215	267	160.5	105	105	100.5	140.5	146.5	256	421	205.5	123.5	95.5	266		
Total Dissolved Solids (mg/l) (replicate and analysis)																			
TDS 1A	38,198	38,660	39,592	39,624.	40,330	37,586	40,426	38,974	39,282	39,748	38,570	40,462	40,706	39,474	40,048	41,202	41,428	37,440	
TDS 1B	39,086	38,502	39,938	39,842	41,480	37,532	39,188	37,002	40,804	39,800	39,814	41,012	40,510	40,400	39,274	41,634	40,530	37,836	
TDS 2A	38,352	-	41,692	-	-	37,754	-	-	-	-	-	38,446	-	38,456	-	-	-	-	
TDS 2B	38,212	-	40,802	-	-	37,040	-	-	-	-	-	38,514		38,166	-		-		
TDS 3A	38,406	-	40,078	-	-	36,944	-	-	-	-	-	38,344	-	41,374					
TDS 3B	39,516	-	40,328	-	-	36,968	-	-	-	-	-	38,096	-	41,064		-	-	-	
Average TDS	38,628	38,581	40,405	39,733	40,905	37,304	39,807	37,988	40,043	39,814	39,202	39,366	40,608	39,822	39,661	41,418	40,979	37,638	
Ionic Composition (mg/L)																			
Sodium (Na)	8,080	8,550	8,580	8,670	7,990	8,010	9,020	8,730	8,420	9,090	9,190	8,510	10,210	9,110	9,210	9,130	8,540		
Chloride (Cl)	29,400	15,500	15,500	15,900	16,200	15,400	15,800	15,900	16,700	16,700	16,700	16,500	16,300	16,000	15,800	16,700	16,700		
Potassium (K)	416	420	428	421	432	392	422	428	424	430	424	429	421	425	423	435	421		
Sulfate (SO4)	9,087	10,316	9,918	9,667	9,917	9,667	9,312	9,918	8,929	10,317	8,872	9,594	8,872	10,600	9,667	10,127	9,771		
Calcium (Ca)	1,287	1,347	1,370	1,312	1,570	1,214	1,400	1,480	1,470	1,420	1,420	1,510	1,500	1,500	1,440	1,490	1,500		
Magnesium (Mg)	1,364	1,412	1,242	1,390	1,294	1,123	1,191	1,245	1,395	1,240	1,279	1,362	1,369	1,200	1,274	1,275	1,299		
Bicarbonate (HCO3)	82	96	103	103	96	89	137	137	116	116	130	96	110	123	116	116	96		
Sum of Ions	49,716	37,641	37,141	37,463	37,499	35,895	37,282	37,838	37,504	39,313	38,015	38,001	38,702	39,038	37,938	39,273	38,347		
Proportion of Ions																			Average
Sodium (Na)	0.163	0.227	0.231	0.231	0.213	0.223	0.242	0.231	0.225	0.231	0.242	0.224	0.263	0.229	0.243	0.232	0.233		0.232
Chloride (Cl)	0.591	0.412	0.417	0.424	0.432	0.429	0.424	0.420	0.445	0.425	0.439	0.434	0.420	0.422	0.417	0.425	0.435		0.426
Potassium (K)	0.008	0.011	0.012	0.011	0.012	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011		0.011
Sulfate (SO4)	0.183	0.274	0.267	0.258	0.264	0.269	0.250	0.262	0.239	0.262	0.233	0.252	0.229	0.266	0.255	0.250	0.255		0.256
Calcium (Ca)	0.026	0.036	0.037	0.035	0.042	0.034	0.038	0.039	0.039	0.036	0.037	0.040	0.039	0.038	0.038	0.038	0.039		0.038
Magnesium (Mg)	0.027	0.038	0.033	0.037	0.035	0.031	0.032	0.033	0.037	0.032	0.034	0.036	0.035	0.032	0.034	0.032	0.034		0.034
Bicarbonate (HCO3)	0.002	0.003	0.003	0.003	0.003	0.002	0.004	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003		0.003
FIELD DATA																			
Conductivity (mmhos/cm)	38.20	39.90	40.37	40.70	40.70	38.63	40.70	40.80	41.67	41.00	40.90	43.73	42.20	43.12	41.00	40.80	41.20	40.97	
Temperature (C)	15.34	15.60	14.97	15.00	14.80	15.57	15.60	15.30	16.17	14.85	14.90	19.00	17.10	17.56	14.85	14.86	22.47	16.92	
Conductivity @ 25C	46.84	48.63	49.94	50.31	50.55	47.12	49.61	50.08	50.12	50.86	50.68	49.37	49.70	50.26	50.86	50.60	43.58	40.45	

Note: See Figure F-1 for location of sampling stations. Replicate samples were collected at most surface locations for TDS analysis. Duplicate analyses were also run on each of the TDS samples collected on January 21, 1986. Ionic composition was analyzed for sample IA.

Source: Parsons, 1986

Table F-1 (Contd)

Constituent	1B Surf	1B Mid	1B Bot	4B Surf	4B Mid	4B Bot	6B Surf	6B Mid	6B Bot	9B Surf	9B Mid	9B Bot	13B Surf	13B Mid	13B Bot	15B Surf	15B Mid	15B Bot	Average	2 day Average
	Station/Depth January 22, 1986																			
LABORATORY DATA																				
Suspended Solids (mg/l)	109.5	137	215.5	172.5	109.5	153	120.5	131.5	141.5	193	208	247	128	92.5	95	124.5	124.5	97		
Total Dissolved Solids (mg/l) (replicate and analysis)																				
TDS 1A	37,340	37,368	38,390	39,214	38,124	38,964	40,120	39,536	39,970	39,740	38,398	40,850	38,176	40,430	39,698	38,924	37,796	38,327		
TDS 2A	39,196	-	-	40,674	.	.	41,782	.	-	39,824	-		38,176			39,294	-			
TDS 3A	41,416	-	-	38,302	-	.	39,694	.	-	37,990	-		39,260	.	.	39,066	.			
Average TDS	39,317	37,368	38,390	39,397	38,124	38,964	40,532	39,536	39,970	39,251	38,398	40,850	38,537	40,438	39,698	39,095	37,796	38,327		
Ionic Composition (mg/l)																				
Sodium (Na)	9,000	10,900	10,040	9,660	10,000	10,370	9,690	9,790	9,950	9,630	9,350	9,549	9,250	8,450	9,550	9,480	9,600	9,700		
Chloride (Cl)	16,200	14,700	16,400	16,000	16,900	16,500	16,200	16,500	16,300	16,100	15,600	16,300	16,300	16,000	16,600	16,200	16,100	16,600		
Potassium (K)	394	400	398	396	407	404	405	411	411	403	404	400	411	416	420	415	418	415		
Sulfate (SO4)	9,375	9,549	9,514	9,566	9,722	9,601	9,705	9,740	9,933	9,375	9,592	9,175	9,583	9,852	9,844	9,722	9,497	9,809		
Calcium (Ca)	1,185	1,181	1,175	1,215	1,204	1,239	1,226	1,216	1,301	1,258	1,242	1,273	1,254	1,208	1,267	1,193	1,190	1,261		
Magnesium (Mg)	1,259	1,355	1,159	1,270	1,365	1,376	1,304	1,424	1,413	1,337	1,295	1,441	1,432	1,399	1,473	1,146	1,125	1,349		
Bicarbonate (HCO3)	212	253	200	219	253	267	247	267	267	234	226	219	226	267	267	219	260	274		
Sum of Ions	37,705	38,346	38,606	38,326	39,851	39,757	38,780	39,349	39,625	38,337	37,709	38,557	38,456	38,472	39,421	38,375	38,180	39,408		
Proportion of Ions																				
Sodium (Na)	0.241	0.204	0.258	0.252	0.251	0.261	0.250	0.249	0.251	0.251	0.246	0.248	0.241	0.233	0.242	0.247	0.251	0.246	0.250	0.242
Chloride (Cl)	0.430	0.383	0.422	0.417	0.424	0.415	0.418	0.419	0.411	0.420	0.414	0.423	0.424	0.424	0.421	0.422	0.422	0.421	0.418	0.422
Potassium (K)	0.010	0.011	0.010	0.010	0.010	0.010	0.011	0.010	0.010	0.011	0.011	0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011
Sulfate (SO4)	0.249	0.249	0.245	0.250	0.244	0.241	0.250	0.248	0.252	0.245	0.254	0.243	0.249	0.256	0.250	0.253	0.249	0.249	0.249	0.252
Calcium (Ca)	0.031	0.031	0.030	0.032	0.030	0.031	0.032	0.031	0.033	0.033	0.033	0.033	0.033	0.033	0.032	0.031	0.031	0.032	0.032	0.035
Magnesium (Mg)	0.033	0.035	0.030	0.033	0.034	0.035	0.034	0.036	0.036	0.035	0.034	0.037	0.037	0.036	0.037	0.030	0.029	0.034	0.034	0.034
Bicarbonate (HCO3)	0.006	0.007	0.005	0.006	0.006	0.007	0.006	0.007	0.007	0.006	0.006	0.006	0.006	0.007	0.007	0.006	0.007	0.007	0.006	0.005
FIELD DATA																				
Conductivity (mmhos/cm)	40.74	40.7	40.8	39.84	40.50	40.80	40.92	40.60	40.20	40.69	40.50	40.40	40.93	40.20	40.90	41.74	40.60	40.90		
Temperature (C)	16.49	16.6	16.4	15.96	15.30	15.30	15.79	14.90	14.90	16.47	16.00	15.70	16.92	14.90	15.00	17.04	14.90	14.80		
Conductivity @ 25C	48.65	48.48	48.82	48.15	49.71	50.00	49.65	50.30	50.43	48.61	48.91	49.13	48.40	49.81	50.56	49.22	50.55	50.80		

Note: See Figure F-1 for location of sampling stations. Replicate samples were collected at all surface locations for TDS analysis. Ionic composition was analyzed for water sample 1A.
Source: Parsons, 1986.

Table F-2 - Salton Sea Temperature Profiles (Parsons, 1986)

DEPTH (FEET)	TEMPERATURE (C) JAN 21,1986									
STATION	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A
TIME (PST)	0746	0837	0900	0912	0941	0957	1008	1050	1108	1120
SURFACE	15.34	15.02	15.11	14.97	15.50	15.25	15.57	15.33	16.27	15.78
1.0	15.41	15.04	15.12	14.99	15.50	15.27	15.58	15.34	16.27	15.78
2.0	15.62	15.04	15.11	15.00	15.51	15.26	15.58	15.34	16.21	15.74
3.0	15.69	15.06	15.10	14.98	15.49	15.24	15.62	15.32	16.13	15.69
4.0	15.68	15.05	15.11	15.00	15.46	15.18	15.89	15.21	16.03	15.60
5.0	15.64	15.06	15.11	14.99	15.43	15.21	15.97	15.38	15.91	15.51
6.0	15.63	15.08	15.10	14.99	15.44	15.43	15.87	15.56	15.83	15.40
7.0		15.09	15.09	14.99	15.38	15.70	15.86		15.80	15.35
8.0		15.11	15.09	14.99	15.34	15.89	15.83		15.70	15.31
9.0		15.10	15.06	14.98	15.34	15.92	15.67		15.66	15.28
10.0		15.08	15.05	14.97	15.33	15.92	15.63		15.63	15.28
11.0		15.02	15.06	14.99	15.33	15.93	15.60		15.64	15.26
12.0		14.98	15.07	15.00	15.32	15.92	15.60		15.62	15.24
13.0		14.94	15.03	14.99	15.32	15.86	15.56		15.55	15.23
14.0		14.92	15.01	14.99	15.31	15.77	15.40		15.45	15.22
15.0		14.88	15.00	14.99	15.26	15.55	15.34		15.42	15.20
16.0		14.89	14.98	15.01	15.23	15.52	15.27		15.40	15.20
17.0		14.88	14.98	15.04	15.22	15.61	15.27		15.32	15.20
18.0		14.89	14.98	15.02	15.19	15.56	15.26		15.32	15.19
19.0		14.91	14.99	15.01	15.18	15.56	15.23		15.29	15.17
20.0		14.89	14.99	15.04	15.17	15.58	15.24		15.24	15.14
21.0		14.88	15.00	15.04	15.15	15.51	15.28		15.22	15.13
22.0		14.89	15.01	15.03	15.15	15.36			15.21	15.12
23.0		14.89	15.00	15.04	15.13	15.34			15.21	15.11
24.0		14.90	15.01	15.06	15.12	15.36			15.23	15.11
25.0		14.91	15.02	15.01	15.12	15.31			15.26	15.11
26.0		14.92	15.01	15.00	15.12	15.28			15.30	15.11
27.0			15.03	14.98	15.11	15.27			15.31	15.12
28.0			15.05	14.97	15.12	15.25			15.32	15.13
29.0			15.07	14.96	15.12	15.24			15.32	15.12
30.0			15.07	14.95	15.12	15.23			15.32	15.13
31.0			15.08	14.97	15.12	15.22			15.34	15.12
32.0			15.09	14.95	15.10	15.23			15.33	15.12
33.0			15.09	14.95	15.11	15.22			15.33	15.12
34.0			15.08	14.93	15.10	15.23				15.12
35.0			15.07	14.90	15.11	15.21				15.12
36.0			15.06	14.86	15.11	15.20				15.12
37.0			15.05	14.83	15.11	15.19				15.12
38.0			15.05	14.84	15.11	15.19				15.11
39.0			15.05	14.79	15.11	15.19				15.11
40.0			15.06	14.77	15.11					15.11
41.0			15.04	14.75	15.10					15.10
42.0			15.04	14.78	15.09					15.08
43.0			15.05	14.77	15.05					15.06
44.0				14.78	15.03					15.05
45.0					15.05					
46.0										
47.0										
48.0										
49.0										
50.0										

Table F-2 (Contd)

DEPTH (FEET)	TEMPERATURE (C) JAN 21,1986									
STATION	11A	12A	13A	14A	15A	16A	17A	18A	19A	20A
TIME (PST)	1131	1210	1229	1301	1314	1332	1345	1409	1428	1501
SURFACE	15.78	16.17	16.97	17.25	19.00	19.21	17.56	22.47	16.92	19.92
1.0	15.76	16.16	16.87	17.23	18.97	19.17	17.11	18.54	17.13	19.51
2.0	15.65	16.14	16.64	16.93	18.72	18.00	16.41	16.80	15.87	17.73
3.0	15.55	16.10	16.24	16.31	18.47	16.92	15.80	16.46	15.48	16.57
4.0	15.40	15.98	16.01	15.85	17.76	16.41	15.51	16.07	15.31	16.11
5.0	15.32	15.91	15.79	15.72		16.14	15.38	15.81	15.16	16.11
6.0	15.29	15.68	15.63	15.64		16.00	15.30	15.73	15.14	
7.0	15.29	15.57	15.56	15.55		15.75	15.26	15.50	15.13	
8.0	15.29	15.54	15.52	15.45		15.73	15.24	15.48	15.12	
9.0	15.29	15.54	15.50	15.40		15.71	15.20	15.42	15.11	
10.0	15.31	15.52	15.49	15.29		15.70	15.17	15.44	15.12	
11.0	15.30	15.50	15.47	15.20		15.70	15.10	15.43	15.11	
12.0	15.29	15.48	15.43	15.15		15.70	14.99	15.32	15.11	
13.0	15.29	15.43	15.39	15.10		15.69	14.92	15.29	15.12	
14.0	15.26	15.39	15.27	15.10			14.87	15.29	15.12	
15.0	15.23	15.32	15.14	15.09			14.85	15.29	15.15	
16.0	15.20	15.22	15.08	15.08			14.84	15.30	15.18	
17.0	15.19	15.15	15.03	15.06			14.84	15.30	15.21	
18.0	15.18	15.12	15.00	15.03			14.83	15.28	15.28	
19.0	15.17	15.10	14.95	15.02			14.84	15.28	15.34	
20.0	15.15	15.07	14.93	14.99			14.85	15.28	15.36	
21.0	15.15	14.98	14.93	14.97			14.86	15.26	15.38	
22.0	15.12	14.89	14.92	14.96			14.87	15.24	15.40	
23.0	15.12	14.84	14.91	14.95			14.85	15.24	15.40	
24.0	15.10	14.82	14.89	14.94			14.86		15.40	
25.0	15.06	14.80	14.90	14.93			14.87		15.41	
26.0	15.01	14.80	14.93	14.91			14.87		15.41	
27.0	15.00	14.80	14.92	14.90			14.87		15.40	
28.0	14.97	14.80	14.91	14.91			14.87		15.38	
29.0	14.97	14.79	14.90	14.93			14.88		15.36	
30.0	14.98	14.79	14.90	14.93			14.87		15.35	
31.0	14.99	14.80	14.90	14.93			14.86		15.36	
32.0	14.99	14.79	14.89	14.94					15.36	
33.0	14.99	14.79	14.90	14.94						
34.0	14.97	14.81	14.89	14.96						
35.0	14.95	14.82	14.90	14.94						
36.0	14.94	14.81	14.90							
37.0	14.93	14.82	14.89							
38.0	14.93	14.86	14.89							
39.0	14.92	14.88	14.90							
40.0	14.91	14.88	14.88							
41.0	14.90	14.90	14.89							
42.0	14.88	14.91	14.88							
43.0	14.87	14.90								
44.0	14.86	14.91								
45.0	14.86	14.91								
46.0	14.86	14.91								
47.0		14.92								
48.0										
49.0										
50.0										

Table F-2 (Contd)

DEPTH (FEET)	TEMPERATURE (C) JAN 22,1986								
STATION	1B	2B	3B	4B	5B	6B	7B	9B	10B
TIME (PST)	0822	0848	0902	0915	0934	0945	1004	1021	1035
SURFACE	16.49	15.67	16.12	15.96	15.92	15.79	16.07	16.47	16.22
1.0	16.52	15.68	16.14	15.99	15.94	15.81	16.08	16.47	16.23
2.0	16.53	16.03	16.12	15.99	15.94	15.81	16.00	16.33	16.16
3.0	16.54	16.48	16.10	15.99	15.94	15.77	15.76	16.11	16.09
4.0	16.55	16.45	16.08	15.97	15.91	15.70	15.75	15.95	15.93
5.0	16.56	16.21	15.92	15.86	15.91	15.66	15.65	15.87	15.86
6.0	16.56	16.21	15.63	15.66	15.89	15.64	15.61	15.78	
7.0	16.55	16.13	15.50	15.48	15.82	15.63	15.59	15.74	
8.0	16.55	15.98	15.45	15.39	15.67	15.63	15.56		
9.0	16.54	15.94	15.43	15.35	15.45	15.63	15.54		
10.0	16.39	15.87	15.42	15.34	15.23	15.62	15.52		
11.0		15.84	15.43	15.33	15.06	15.57	15.50		
12.0		15.69	15.44	15.33	15.03	15.46	15.48		
13.0		15.59	15.46	15.33	14.95	15.35	15.46		
14.0		15.58	15.45	15.33	14.88	15.23	15.42		
15.0		15.53	15.43	15.32	14.84	15.11	15.40		
16.0		15.55	15.44	15.31	14.85	14.94	15.40		
17.0		15.52	15.41	15.31	14.86	14.89	15.40		
18.0		15.44	15.39	15.32	14.87	14.85	15.35		
19.0		15.43	15.37	15.31	14.89	14.85	15.29		
20.0		15.44	15.36	15.31	14.91	14.85	15.24		
21.0		15.44	15.36	15.31	14.92	14.85	15.21		
22.0		15.43	15.34	15.31	14.94	14.86	15.19		
23.0		15.39	15.31	15.29	14.96	14.87	15.14		
24.0		15.37	15.30	15.31	14.94	14.89	15.13		
25.0		15.36	15.29	15.30	14.95	14.91	15.11		
26.0		15.34	15.15	15.29	14.97	14.91	15.06		
27.0		15.33	15.05	15.29	14.96	14.91	15.04		
28.0		15.32	15.05	15.29	14.96	14.92	15.01		
29.0		15.26	15.07	15.29	14.96	14.92	14.98		
30.0		15.22	15.06	15.29	14.96	14.91	14.99		
31.0		15.20	15.07		14.96	14.92	15.00		
32.0		15.20	15.06		14.96	14.92	14.99		
33.0		15.19	15.07		14.94	14.92	14.98		
34.0		15.22	15.07		14.93	14.92	14.98		
35.0		15.24	15.07		14.95	14.93	14.97		
36.0		15.24	15.06		14.93	14.92	14.97		
37.0			15.07		14.94	14.93	14.99		
38.0					14.93	14.92	14.99		
39.0					14.94	14.92			
40.0					14.94	14.93			
41.0					14.94	14.94			
42.0					14.95	14.93			
43.0						14.92			
44.0						14.91			
45.0						14.92			
46.0						14.92			
47.0									
48.0									
49.0									
50.0									

Table F-2 (Contd)

DEPTH (FEET)	TEMPERATURE (C) JAN 22,1986							
STATION	11B	12B	13B	14B	15B	16B	17B	18B
TIME (PST)	1046	1057	1113	1131	1143	1158	1222	1234
SURFACE	16.28	16.19	16.92	16.51	17.04	16.44	18.09	16.62
1.0	16.23	16.16	16.37	16.52	16.92	16.40	18.05	16.64
2.0	16.13	15.85	16.05	16.28	16.43	16.25	17.20	16.61
3.0	16.00	15.55	15.91	16.03	16.30	16.02	16.55	16.60
4.0	15.92	15.48	15.78	15.81	16.19	15.91	16.34	16.55
5.0	15.85	15.42	15.72	15.75	15.85	15.70	16.30	16.60
6.0	15.79	15.41	15.64	15.64	15.70	15.40	16.18	16.43
7.0	15.75	15.44	15.60	15.59	15.62	15.24	15.98	16.08
8.0	15.72	15.44	15.55	15.47	15.56	15.10	15.81	15.96
9.0	15.64	15.43	15.44	15.32	15.33	15.03	15.65	15.91
10.0	15.54	15.42	15.25	15.19	15.14	15.00	15.44	15.89
11.0		15.40	15.13	15.07	15.05	14.97	15.16	15.85
12.0		15.40	15.09	15.03	15.00	14.95	15.09	15.81
13.0		15.39	15.06	14.97	14.95	14.93	15.06	15.79
14.0		15.39	14.99	14.95	14.92	14.87	15.01	15.82
15.0		15.40	14.92	14.95	14.88	14.88	14.94	15.79
16.0		15.39	14.89	14.94	14.88	14.87	14.88	15.76
17.0		15.39	14.89	14.95	14.84	14.87	14.85	15.72
18.0		15.38	14.87	14.92	14.82	14.86	14.84	15.63
19.0		15.36	14.85	14.93	14.77	14.84	14.82	15.52
20.0		15.35	14.87	14.96	14.74	14.82	14.81	15.41
21.0		15.36	14.86	14.94	14.76	14.83	14.81	15.32
22.0		15.35	14.85	14.93	14.78	14.83	14.78	15.26
23.0		15.31	14.84	14.92	14.82	14.85	14.82	15.22
24.0		15.23	14.83	14.95	14.85	14.85	14.83	15.19
25.0		15.17	14.85	14.90	14.84	14.86	14.84	15.18
26.0		15.14	14.86	14.92	14.86	14.87	14.88	15.16
27.0		15.10	14.83	14.86	14.89	14.88	14.90	15.15
28.0		15.02	14.83	14.85	14.90	14.87	14.90	15.11
29.0		15.00	14.85	14.86	14.91	14.88	14.90	15.10
30.0		15.00	14.86	14.87	14.90	14.87	14.92	15.09
31.0		15.02	14.85	14.87	14.89	14.88	14.92	15.07
32.0		15.01	14.85	14.86	14.90	14.88	14.86	15.05
33.0		14.98	14.86	14.86	14.91	14.87	14.77	15.02
34.0		14.99	14.88	14.85	14.89	14.87	14.75	15.00
35.0		14.98	14.92	14.87	14.89	14.89	14.75	14.99
36.0		15.00	14.96	14.87	14.91	14.87	14.75	14.98
37.0		14.99	14.96	14.89	14.91	14.88	14.77	14.97
38.0		15.00	14.96	14.88	14.90	14.87	14.78	14.98
39.0		14.99	14.96	14.86	14.90	14.88	14.82	15.02
40.0		15.01	14.95	14.85	14.88	14.88	14.86	15.05
41.0		15.00	14.94	14.86	14.90	14.87	14.90	15.07
42.0		15.00	14.94	14.81	14.89	14.88	14.91	15.08
43.0				14.86	14.86	14.89	14.91	
44.0				14.82	14.83	14.88	14.93	
45.0				14.81	14.82	14.88	14.92	
46.0				14.81	14.82	14.89		
47.0				14.82	14.82	14.88		
48.0					14.82	14.88		
49.0								
50.0								

Table F-3 - Salton Sea Conductivity Profiles
(Parsons, 1986)

DEPTH (FEET)	CONDUCTIVITY (mmhos) @ 25 C JAN 21,1986									
STATION	1A	2A	3A	4A	5A	6A	7A	8A	9A	10A
TIME (PST)	0746	0837	0900	0912	0941	0957	1008	1050	1108	1120
SURFACE	46.84	47.72	49.50	49.94	50.06	47.77	47.12	47.86	49.14	50.22
1.0	48.05	47.69	49.45	49.89	50.06	47.74	47.08	47.85	49.22	50.20
2.0	48.01	47.63	49.51	49.91	50.02	47.76	47.09	47.84	49.23	50.27
3.0	48.33	47.62	49.56	49.96	50.04	48.04	47.43	47.81	49.34	50.32
4.0	48.67	47.60	49.53	49.94	50.07	48.23	47.97	47.87	49.43	50.40
5.0	48.67	47.58	49.50	49.96	50.11	48.50	48.68	47.68	49.50	50.49
6.0	48.57	47.47	49.54	49.96	50.10	48.72	49.24	47.52	49.55	50.49
7.0		47.35	49.63	49.98	50.17	49.12	49.34		49.59	50.45
8.0		47.19	49.62	50.02	50.22	49.41	49.44		49.70	50.48
9.0		47.16	49.68	50.04	50.18	49.49	49.44		49.70	50.56
10.0		47.10	49.75	50.06	50.20	49.51	49.51		49.78	50.48
11.0		47.07	49.74	50.06	50.16	49.48	49.57		49.71	50.49
12.0		47.02	49.78	50.07	50.18	49.50	49.58		49.70	50.44
13.0		46.82	49.85	50.13	50.18	49.55	49.64		49.77	50.48
14.0		46.97	49.88	50.13	50.21	49.61	49.72		49.87	50.42
15.0		47.08	49.91	50.15	50.25	49.78	49.78		50.00	50.42
16.0		47.10	49.96	50.15	50.30	49.70	49.89		50.09	50.43
17.0		47.14	49.99	50.16	50.26	49.64	49.93		50.20	50.40
18.0		47.17	50.02	50.17	50.29	49.69	49.97		50.23	50.45
19.0		47.15	50.02	50.28	50.28	49.65	49.99		50.28	50.44
20.0		47.22	50.03	50.29	50.30	49.59	50.04		50.34	50.44
21.0		47.22	50.04	50.29	50.28	49.59	50.09		50.39	50.43
22.0		47.22	50.01	50.30	50.26	49.75			50.38	50.44
23.0		47.35	50.05	50.30	50.25	49.77			50.39	50.43
24.0		47.86	50.05	50.30	50.27	49.80			50.40	50.45
25.0		48.18	50.04	50.38	50.27	49.85			50.42	50.47
26.0		47.95	50.09	50.41	50.25	49.87			50.40	50.47
27.0			50.06	50.41	50.28	49.92			50.41	50.45
28.0			50.07	50.45	50.27	50.06			50.44	50.44
29.0			50.08	50.45	50.25	50.04			50.46	50.46
30.0			50.11	50.47	50.26	50.03			50.44	50.44
31.0			50.10	50.47	50.26	49.98			50.42	50.46
32.0			50.10	50.47	50.27	49.94			50.45	50.44
33.0			50.10	50.46	50.25	49.95			50.48	50.45
34.0			50.08	50.48	50.25	50.03				50.44
35.0			50.09	50.53	50.23	50.09				50.44
36.0			50.09	50.52	50.24	50.08				50.44
37.0			50.10	50.56	50.23	50.09				50.45
38.0			50.12	50.55	50.23	50.11				50.45
39.0			50.14	50.56	50.25	50.20				50.44
40.0			50.14	50.60	50.25					50.44
41.0			50.19	50.63	50.29					50.45
42.0			50.23	50.62	50.29					50.46
43.0			50.23	50.62	50.31					50.49
44.0				50.60	50.33					50.49
45.0					50.32					
46.0										
47.0										
48.0										
49.0										
50.0										

Table F-3 (Contd)

DEPTH (FEET)	CONDUCTIVITY (mmhos) @ 25 C JAN 21, 1986									
STATION	11A	12A	13A	14A	15A	16A	17A	18A	19A	20A
TIME (PST)	1131	1210	1229	1301	1314	1332	1345	1409	1428	1501
SURFACE	50.29	50.12	50.12	49.61	49.39	49.05	50.26	43.38	48.45	45.59
1.0	50.26	50.20	50.24	49.60	49.32	49.10	50.61	47.68	48.55	45.85
2.0	50.30	50.18	50.48	49.88	49.37	48.76	51.12	49.36	49.75	47.78
3.0	50.36	50.17	50.94	50.49	49.41	49.50	51.54	49.91	49.81	49.27
4.0	50.43	50.20	51.22	50.63	49.18	49.48	52.02	50.76	49.80	49.90
5.0	50.45	50.24	51.43	50.40	49.72	49.85	52.28	51.20	49.90	49.96
6.0	50.46	50.44	50.84	50.45		50.29	51.82	51.58	49.94	
7.0	50.42	50.58	51.17	50.68		50.42	51.91	51.05	49.97	
8.0	50.41	50.58	50.86	50.82		50.14	51.60	50.51	49.92	
9.0	50.42	50.51	50.78	50.87		50.04	51.36	50.29	49.97	
10.0	50.40	50.51	50.61	50.68		50.16	51.00	50.09	49.92	
11.0	50.42	50.48	50.51	50.36		50.27	51.25	50.09	50.01	
12.0	50.41	50.50	50.43	50.24		50.33	51.47	50.25	50.06	
13.0	50.46	50.54	50.42	50.20		50.52	51.08	50.16	50.07	
14.0	50.49	50.55	50.51	50.29			50.93	50.29	50.03	
15.0	50.51	50.62	50.55	50.34			50.91	50.30	49.92	
16.0	50.55	50.70	50.68	50.34			50.89	50.38	49.90	
17.0	50.53	50.66	50.74	50.26			50.85	50.58	49.90	
18.0	50.50	50.59	50.87	50.35			50.75	50.25	49.89	
19.0	50.49	50.56	50.97	50.18			50.70	50.48	49.99	
20.0	50.49	50.60	51.08	50.29			50.78	50.45	50.03	
21.0	50.47	50.75	50.85	50.23			50.77	50.26	50.06	
22.0	50.49	50.92	50.72	50.32			50.86	50.17	50.07	
23.0	50.49	50.83	50.66	50.37			50.72	50.30	50.12	
24.0	50.50	50.76	50.71	50.36			50.74		50.13	
25.0	50.52	50.77	50.69	50.30			50.62		50.16	
26.0	50.53	50.77	50.66	50.32			50.58		50.16	
27.0	50.51	50.72	50.67	50.34			50.55		50.17	
28.0	50.53	50.66	50.68	50.33			50.53		50.18	
29.0	50.54	50.68	50.70	50.38			50.46		50.22	
30.0	50.53	50.67	50.72	50.38			50.47		50.24	
31.0	50.54	50.64	50.75	50.38			50.49		50.22	
32.0	50.53	50.68	50.75	50.37					50.25	
33.0	50.52	50.71	50.74	50.41						
34.0	50.57	50.70	50.76	50.39						
35.0	50.59	50.69	50.75	50.45						
36.0	50.63	50.70	50.74							
37.0	50.64	50.70	50.73							
38.0	50.63	50.66	50.73							
39.0	50.64	50.63	50.71							
40.0	50.67	50.64	50.75							
41.0	50.69	50.64	50.71							
42.0	50.74	50.62	50.74							
43.0	50.72	50.65								
44.0	50.74	50.66								
45.0	50.74	50.66								
46.0	50.76	50.65								
47.0		50.66								
48.0										
49.0										
50.0										

Table F-3 (Contd)

DEPTH (FEET)	CONDUCTIVITY (mmhos) @ 25 C JAN 22,1986								
STATION	1B	2B	3B	4B	5B	6B	7B	9B	10B
TIME (PST)	0822	0848	0902	0915	0934	0945	1004	1021	1035
SURFACE	48.65	47.93	47.97	48.15	49.24	49.65	48.13	48.61	47.11
1.0	48.56	47.85	47.80	48.00	49.17	49.57	47.88	48.60	47.32
2.0	48.56	47.48	47.83	48.24	49.02	49.41	47.84	48.78	47.68
3.0	48.59	47.28	47.88	48.34	49.04	49.45	48.26	48.89	47.63
4.0	48.58	47.41	48.25	48.24	49.08	49.40	48.62	48.90	47.86
5.0	48.53	48.56	48.76	48.37	49.05	49.47	48.78	48.95	48.19
6.0	48.55	48.94	49.39	48.52	49.12	49.56	48.80	48.97	
7.0	48.56	49.18	49.56	48.96	49.24	49.60	48.79	49.01	
8.0	48.59	49.32	49.58	49.49	49.39	49.64	48.76		
9.0	48.60	49.37	49.61	49.69	49.65	49.66	48.80		
10.0	48.79	49.39	49.62	49.78	49.87	49.69	48.93		
11.0		49.47	49.62	49.81	50.07	49.75	48.95		
12.0		49.70	49.63	49.80	50.14	49.87	48.96		
13.0		49.72	49.66	49.81	50.16	49.99	49.05		
14.0		49.78	49.71	49.77	50.26	50.09	49.11		
15.0		49.86	49.84	49.76	50.30	50.19	49.14		
16.0		49.79	49.85	49.74	50.29	50.32	49.14		
17.0		49.82	49.92	49.75	50.31	50.37	49.13		
18.0		49.88	49.97	49.82	50.36	50.36	49.20		
19.0		49.93	49.98	49.85	50.35	50.37	49.27		
20.0		49.95	50.02	49.86	50.35	50.39	49.33		
21.0		49.94	50.02	49.88	50.35	50.40	49.35		
22.0		49.90	50.05	49.94	50.34	50.40	49.20		
23.0		49.97	50.08	49.97	50.33	50.39	49.79		
24.0		50.02	50.10	49.93	50.42	50.39	49.91		
25.0		50.02	50.12	49.97	50.42	50.39	49.99		
26.0		50.07	50.25	49.99	50.41	50.43	50.06		
27.0		50.11	50.29	50.01	50.42	50.45	50.09		
28.0		50.14	50.28	50.01	50.44	50.43	50.14		
29.0		50.20	50.28	50.03	50.45	50.44	50.17		
30.0		50.20	50.26	50.05	50.45	50.45	50.13		
31.0		50.20	50.25		50.45	50.44	50.16		
32.0		50.20	50.29		50.45	50.45	50.27		
33.0		50.21	50.27		50.50	50.45	50.33		
34.0		50.17	50.26		50.48	50.44	50.37		
35.0		50.21	50.27		50.44	50.44	50.39		
36.0		50.20	50.29		50.49	50.46	50.39		
37.0			50.29		50.44	50.44	50.37		
38.0					50.44	50.45	50.42		
39.0					50.42	50.44			
40.0					50.41	50.44			
41.0					50.41	50.40			
42.0					50.41	50.41			
43.0						50.43			
44.0						50.42			
45.0						50.39			
46.0						50.43			
47.0									
48.0									
49.0									
50.0									

Table F-3 (Contd)

DEPTH (FEET)	CONDUCTIVITY (mmhos) @ 25 C JAN 22, 1986							
STATION	11B	12B	13B	14B	15B	16B	17B	18B
TIME (PST)	1046	1057	1113	1131	1143	1158	1222	1234
SURFACE	47.90	49.15	48.40	49.78	49.22	49.75	49.11	48.88
1.0	47.86	49.12	48.97	49.52	49.32	49.71	49.13	48.73
2.0	47.87	49.41	49.07	49.69	49.84	49.84	49.84	48.76
3.0	47.95	49.69	48.97	49.84	49.88	50.06	50.67	48.78
4.0	48.02	49.54	48.86	49.96	49.71	50.14	50.02	48.82
5.0	48.06	49.51	48.78	49.93	50.00	50.30	50.02	48.76
6.0	48.11	49.48	48.57	49.98	50.22	50.50	50.13	49.01
7.0	48.15	49.49	48.88	49.93	50.19	50.62	50.37	49.62
8.0	48.19	49.55	48.73	50.11	50.18	50.83	50.44	49.83
9.0	48.30	49.60	48.96	50.26	50.49	50.94	50.47	49.96
10.0	48.69	49.63	49.28	50.38	50.72	50.75	50.56	50.03
11.0		49.68	49.51	50.54	50.60	50.89	50.73	50.06
12.0		49.71	49.61	50.48	50.59	50.78	50.66	50.11
13.0		49.75	49.45	50.45	50.62	50.90	50.80	50.15
14.0		49.78	49.13	50.55	50.66	50.84	50.80	50.12
15.0		49.77	49.55	50.53	50.70	50.80	50.76	50.19
16.0		49.79	49.83	50.54	50.74	50.75	50.81	50.22
17.0		49.79	49.90	50.53	50.78	50.71	50.72	50.26
18.0		49.83	49.96	50.59	50.75	50.68	50.89	50.37
19.0		49.85	49.85	50.52	50.72	50.72	50.96	50.47
20.0		49.87	49.91	50.42	50.78	50.74	50.85	50.53
21.0		49.87	49.82	50.48	50.67	50.66	50.81	50.59
22.0		49.91	49.99	50.45	50.68	50.65	50.78	50.61
23.0		49.96	50.11	50.46	50.67	50.72	50.71	50.58
24.0		50.05	50.23	50.36	50.63	50.70	50.71	50.54
25.0		50.11	50.28	50.46	50.74	50.68	50.70	50.53
26.0		50.11	50.29	50.39	50.71	50.69	50.69	50.53
27.0		50.13	50.34	50.50	50.67	50.67	50.69	50.51
28.0		50.23	50.31	50.51	50.65	50.72	50.69	50.58
29.0		50.24	50.31	50.51	50.64	50.67	50.68	50.56
30.0		50.20	50.30	50.50	50.67	50.69	50.65	50.55
31.0		50.10	50.35	50.49	50.70	50.66	50.63	50.57
32.0		50.08	50.37	50.51	50.69	50.69	50.69	50.58
33.0		50.16	50.41	50.50	50.68	50.71	50.73	50.57
34.0		50.20	50.45	50.54	50.74	50.71	50.69	50.60
35.0		50.25	50.44	50.50	50.72	50.66	50.67	50.59
36.0		50.23	50.44	50.48	50.69	50.70	50.67	50.58
37.0		50.24	50.49	50.45	50.69	50.69	50.65	50.60
38.0		50.24	50.53	50.47	50.71	50.70	50.63	50.61
39.0		50.22	50.55	50.53	50.70	50.68	50.62	50.57
40.0		50.21	50.57	50.54	50.72	50.68	50.61	50.54
41.0		50.22	50.60	50.50	50.68	50.72	50.60	50.57
42.0		50.26	50.60	50.59	50.65	50.70	50.60	50.58
43.0				50.47	50.71	50.68	50.64	
44.0				50.58	50.74	50.73	50.59	
45.0				50.60	50.73	50.69	50.61	
46.0				50.61	50.71	50.72		
47.0				50.58	50.72	50.70		
48.0					50.73	50.69		
49.0								
50.0								

Additional data in Table F-1 includes temperature and conductivity measurements at each water sample station. Conductivity values were corrected to 25°C and are also presented. Interpolated values for temperature and corrected conductivity for all 37 stations are presented in Tables F-2 and F-3, respectively. Although no analysis of this data is presented here, temperature and conductivity values have been included. No data was collected at Station 8B.

The proportion of ions was relatively uniform throughout the Salton Sea during the January survey, denoting a well-mixed, stable water body. Table F-4 presents the average ion distribution for the 2-day sampling period versus the distribution for standard ocean water. Although the constituents are the same for both water bodies, the proportion of ions is markedly different. Both sodium and chloride were slightly lower than ocean water, while sulfate was markedly higher. The results of the water samples analyzed between the years 1907 and 1986 show a steady increase in the proportion of sulfate in the Salton Sea over the past 80 years (USDI, 1974a).

Table F-4 - Proportion of Ions in the Salton Sea vs. Standard Ocean Water

Constituent	Salton Sea 1950[a]	Salton Sea 1986	Ocean Water[b]
Sodium (Na)	0.295	0.242	0.306
Chloride (Cl)	0.448	0.422	0.550
Potassium (K)	0.011	0.011	0.011
Sulfate (SO_4)	0.192	0.252	0.077
Calcium (Ca)	0.024	0.035	0.012
Magnesium (Mg)	0.029	0.034	0.037
Bicarbonate (HCO_3)	0.005	0.005	0.004

[a] USDI, 1974a.
[b] Sverdrup, 1942.
Source: Parsons, 1986.

The average TDS concentration ranged from 37,304 mg/L at the surface for Station 7A to 41,418 mg/L at the bottom for Station 17A. The range of replicate samples at any one station was almost as great as the measured spatial variability between stations. For example, replicate TDS values at the surface for Station 17A ranged from 38,166 mg/L to 41,374 mg/L. This is nearly the same as the overall variability for all surface stations measured (36,944 mg/L to 41,782 mg/L). The range of variability (<1% to 10%) observed during the field sampling is within the accuracy acceptable to analysis of TDS (Standard Methods, 1980).

Generally, surface TDS concentrations were greater toward the middle of the basins (Figure F-2). This is consistent with the counterclockwise circulation patterns that generally prevail in the northern and southern hemispheres of the Salton Sea. Surface TDS concentrations were lowest along the northeast edge of the southern hemisphere where there would be an appreciable amount of freshwater input circulated from the Alamo and New Rivers. The TDS concentrations in the northern hemisphere were more uniform with no discernible patterns, except for the higher value measured in the middle of the basin. There were no discernible TDS patterns with depth or for mid-depth or bottom samples.

The average TDS concentrations ranged from 37,304 to 40,979 mg/L at the surface, from 37,368 to 40,438 mg/L at mid-depth, and from 37,988 to 41,418 mg/L at the bottom. The average overall TDS concentration for all Salton Sea data analyzed was 39,327 mg/L, with an average surface value of 39,238 mg/L, a mid-depth value of 39,264 mg/L, and a bottom value of 39,644 mg/L. The overall surface concentrations from the January, 1986, field survey were compared to the semiannual surface water samples that were collected and analyzed by IID during their November 11, 1985, sampling. Table F-5 presents results of this comparison.

Table F-5 - Comparison of TDS Samples Analyzed by the IID (November 1985) vs. Field Survey (January 1986)

Station Identification		Surface TDS (mg/L)		
			Jan.	
Nov.	Jan.	Nov.	Average	Range
Sandy Beach	15A	41,700	39,366	38,446-41,012
Desert Beach	1B	41,110	39,317	37,340-41,416
Salton Sea Beach	9B	41,040	39,251	37,990-39,940
Bertram Station	7A	40,938	37,304	36,944-37,532
Between Alamo and New River Outlets	1A	38,342	38,628	38,198-39,516
Average TDS		40,626	38,773	
Salton Sea elevation (ft)		-227.05	-226.65	
TDS corrected for -226.65 ft elevation and salt loading (January 1986)		39,976	38,773	

Source: Parsons, 1986.

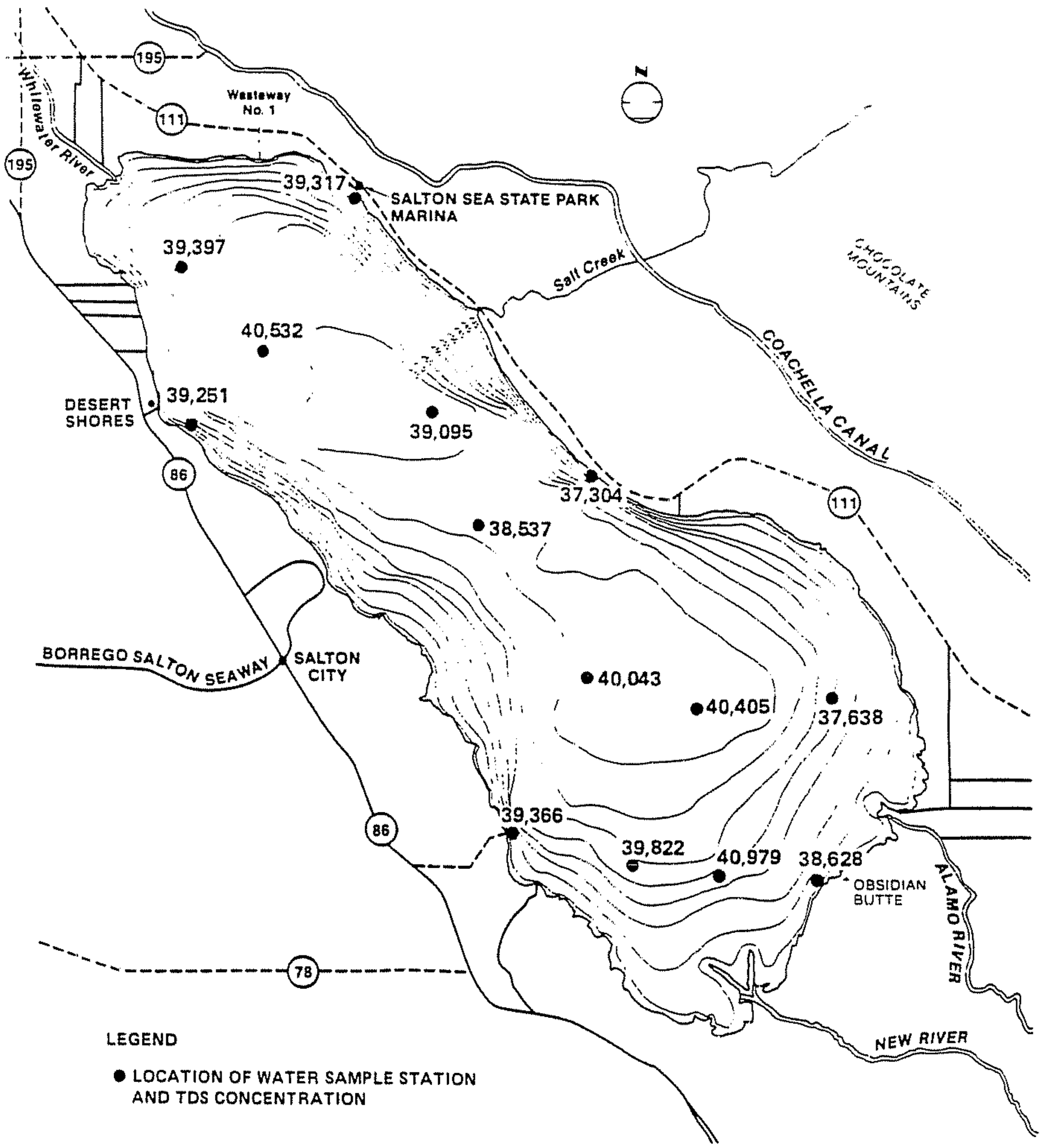


Figure F-2 - Surface TDS Concentrations
(January 21 and 27, 1986)
(Parsons, 1986)

The IID's TDS concentrations were slightly higher than the average of values analyzed from the January survey. However, most of the values were within the range measured for replicate samples. Larger differences are due to sampling procedures, time of year, amount of freshwater input, sampling location, and sea elevation. The sea's elevation during the November, 1985, sampling was 0.4 ft less than the elevation recorded during the January, 1986, field survey. The TDS concentration is inversely proportional to the volume of water in the Salton Sea, accounting for a 1.4% difference in TDS concentrations between the two sampling periods. In addition, salt loading over the 2-month period would account for an approximate 0.2% increase in the salt content of the Salton Sea. The 1.4% elevation and 0.2% salt loading correction factors were applied to the average TDS concentrations presented in Table F-5. Before the correction was applied, there was a less than 5% difference; after the correction, the difference dropped to approximately 3%. Both values are well within the <1% to 10% variation observed for replicate samples collected at the same location during the January survey.

Water samples were collected and analyzed for TSS for all stations and depths (Table F-1). No discernible pattern was observed either between stations or with depths. The average concentration for all TSS samples analyzed was 175.5 mg/L.

F.3 CONCLUSIONS

Based on the January, 1986, sampling study, the TDS concentration (salinity) of the Salton Sea in late January 1986 was approximately 39,300 mg/L. The proportion of ions within the Salton Sea is relatively uniform and stable, yet markedly different from standard ocean water. Salinity distribution in the Salton Sea is influenced by sea elevation, freshwater input, salt loading, circulation patterns, and seasonal stratification. TDS concentrations measured at the IID shoreline stations are not significantly different from measurements taken throughout the Sea. It is recommended that, for all future sampling programs, a minimum of three replicate samples be analyzed for each measured location because of the variability due to analytical procedures.

APPENDIX G

INVENTORY OF WETLAND AND RIPARIAN RESOURCES IN THE IMPERIAL IRRIGATION DISTRICT

CONTENTS

APPENDIX G

INVENTORY OF WETLAND AND RIPARIAN RESOURCES IN THE IMPERIAL IRRIGATION DISTRICT

G.1 SCOPE

The wetland and riparian resources of the Imperial Irrigation District (IID) were inventoried in February 1986. The type and acreage of all wetland and riparian resources were determined using false color, infrared aerial photography (scale 1:12,000) combined with a limited amount of field checking and ground truthing of the photography. Aerial photography was done on February 4, 1986, and field work was conducted from February 17 to 21, 1986. Wetland inventory and characterization was restricted to the following six specific areas:

(1) All-American Canal: from the East Highline Canal confluence to Power Drop No. 3.

(2) East Highline Canal: from the All-American Canal confluence north to the vicinity of Niland.

(3) Alamo River: from the All-American Canal confluence north to the Salton Sea confluence.

(4) New River: from the All-American Canal confluence north to the Salton Sea confluence.

(5) Salt Creek Slough: from its headwaters to the New River confluence.

(6) San Felipe Wash: about a 2- to 3-mile segment near the Salton Sea.

Observations were made regarding plant composition, hydrology, community characteristics, wildlife use, and current land use practices. Opportunistic observations were made of other wetland resources occurring in the IID, but the focus of the field activities was restricted to the flood plains and nearby tributaries and water bodies associated with the six locations listed above. This inventory represents the significant majority of wetland and riparian resources existing within IID's jurisdiction. The inventory also represents an accurate listing of all types and relative abundance of each type present within the IID.

The following description is organized into two major sections. The first section provides a description of wetland resources for the total IID and presents the ecological characteristics of each wetland/riparian type. The second section describes the specific wetland characteristics of each of the six locations listed previously. Comments and observations about wildlife use, specifically for the Yuma clapper rail, are provided when appropriate.

G.2 RESOURCE CHARACTERIZATION

For the purposes of this inventory, wetlands are defined as areas that have one or more of the following three attributes:

(1) At least periodically, the land predominantly supports hydrophytes.

(2) The substrate is predominantly undrained hydric soil.

(3) The substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al., 1979).

In the context of this inventory, riparian communities are considered to be a specialized type of wetland that is restricted to stream and canal banks. Riparian areas are discussed as a separate type because of their predominance in the IID. The nomenclature for wetland and riparian community types follows the conventions established by regional wetland literature (Walters et al., 1980; Ohmart et al., 1977; Grinnell, 1914; Horton, 1977). Fourteen wetland and riparian community types were identified during the inventory. The types are listed in Table G-1. The total acres of each community type by specific location and for the total study area are summarized in Table G-2.

The 14 wetland types represent a mixture of communities that is adapted to a broad continuum of interactions between soil moisture and water salinities. The soil moisture and soil salinity regimes are, in turn, controlled primarily by local hydrology and microtopography. The 14 community types can be segregated into two broad categories, which are distinguished by major differences in plant life form, hydrology, and topography. The two categories are emergent marshes and riparian scrublands or woodlands. The segregation of the IID's wetlands within these two groups is shown in Table G-3. Common reed (*Phragmites*) has been included in both categories because of its common presence in both environmental settings; however, it is most commonly associated with the riparian woodland environment. Ten of the 14 community types were considered members of this broad category.

Table G-1 - Wetland Community Types

Type	Predominant Genus
Salt cedar	_Tamarix_
Cattail	_Typha_
Bulrush	_Scirpus_
Giant reed	_Arundo_
Common reed	_Phragmites_
Saltbush	_Atriplex_
Salt cedar-mesquite	_Tamarix_-_Prosopis_
Saltgrass	_Distichlis_
Arrowweed	_Pluchea_
Iodine bush-seepweed	_Allenrolfea_-_Snaeda_
Seepwillow	_Baccharis_
Rush	_Juncus_
Willow	_Salix_
Salt cedar-arrowweed	_Tamarix_-_Pluchea_

Source: Parsons, 1986a.

Emergent marshes commonly occur in seepage areas, pond and lake shorelines, and oxbow or slough depressions along major flood plains and in larger irrigation return flow ditches. Riparian scrublands and woodlands are extensively distributed along all natural perennial streams, intermittent streams, irrigation canals, and the drier soil zones around seepage areas.

The communities collectively representing the riparian scrublands and woodlands occupy approximately 8,827 acres (95.8%) of the total wetland area surveyed . Of this total, salt cedar and the salt cedar-arrowweed complex are the two most abundant communities. The emergent marsh communities represent about 383 acres (4.2%) of the total wetland acres inventoried. Of these types, cattail is the most abundant and widespread. Common reed was included as a component of the riparian type for this comparison.

A total of 9,210 acres of wetland and riparian resources were inventoried in the survey area (Table G-2). The most abundant and widespread types were salt cedar, salt cedar-arrowweed complex, and arrowweed. Collectively, these types constitute approximately 72.7% of the total wetlands inventoried and, consequently, define the general character of the IID's wetland resource. The greatest proportion of wetlands are located along the New River, Alamo River, All-American Canal, and East Highline Canal (Table G-2). Collectively, these four waterways account for 94.7% of the total wetland acres inventoried. The distribution of total wetlands is shown in Table G-4.

Table G-2 - Summary of Wetland and Riparian Community Types in the IID (acres per area)

Wetland Communities[a]	Salt Creek Slough	San Felipe Wash	All-American Canal	East Highline Canal	Alamo River	New River	Total	Total Wetland Acres (%)
AW	80	11	216	202	169	708	1,386	15.0
AW/SC	-	-	1,084	197	294	633	2,208	24.0
BL	-	4	-	4	2	2	12	0.1
CR	104	10	16	66	196	153	545	5.9
CT	7	14	124	59	61	59	324	3.5
GR	-	-	29	35	1	2	67	0.7
IS	59	-	-	-	39	88	186	2.0
SB	121	6	-	-	212	118	457	5.0
SC	43	27	62	131	1,313	1,522	3,098	33.6
SG	-	-	-	16	-	29	45	0.5
SM	-	-	150	721	-	-	871	9.5
SW	6	-	-	-	2		8	0.1
RU	-	-	-	2	-	-	2	<0.1
WL	-	-	-	-	-	1	1	<0.1
Total	420	72	1,681	1,433	2,289	3,315	9,210	

[a] AW = arrowweed; AW/SC = arrowweed/salt ceder; BL = bulrush; CR = common reed; CT = cattail; GR = giant reed; IS = iodine bush/seepweed; SB = saltbush; SC = salt cedar; SG = saltgrass; SM = salt cedar/mesquite; SW = seepwillow; RU = rush; WL = willow
Source: Parsons, 1986a.

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Table G-3 - Segregation of Wetland and Riparian Community Types in the IID

Emergent Marshes	Riparian Scrublands/Woodlands
Cattail	Salt cedar
Bulrush	Salt cedar-arrowweed
Rush	Common reed
Common reed	Giant reed
Saltgrass	Saltbush
	Salt cedar-mesquite
	Arrowweed
	Iodine bush-seepweed
	Seepwillow
	Willow

Source: Parsons, 1986a.

Table G-4 - Distribution of Wetland Resources Within the IID Inventory Area

Drainage	Total Wetlands (acres)	Percentage of Total Wetland Area (%)
New River	3,315	36.0
Alamo River	2,289	24.8
All-American Canal	1,681	18.2
East Highline Canal	1,433	15.6
Salt Creek Slough	420	4.6
San Felipe Wash	72	0.8
Total	9,210	100.0

Source: Parsons, 1986a.

The following wetland community descriptions are organized in general order of decreasing soil moisture and soil salinity.

G.2.1 CATTAIL COMMUNITY

The cattail community constitutes about 324 acres (3.5%) of the total wetland resource. The community composition is very homogeneous being composed almost entirely of narrow-leaved cattail (Typha angustifolia). Cattail is usually associated with permanent standing freshwater or very highly saturated soils. Narrow-leafed cattail is slightly more tolerant of soil salinities than common cattail. Cattail is most abundant along the New River and the All-American Canal. Typical sites include the margins of shallow ponds, irrigation ditches, and saturated seeps. This community is one of the three communities used by the endangered Yuma clapper rail and is its preferred habitat type, either alone or when combined with common reed (Phragmites australis) or bulrush (Scirpus robustus and S. acutus). Cattail is often intermixed among other types and is bordered by shrublands of salt cedar (Tamarix chinensis), arrowweed (Pluchea sericea), quailbush (Atriplex leutiformus), and common reed.

G.2.2 BULRUSH COMMUNITY

The bulrush community constitutes about 12 acres (0.1%) of the total wetland resource. Community composition is typified by homogeneous stands of either tule or hardstem bulrush (Scirpus acutus), giant bulrush (S. californicus), three square bulrush (S. americanus), or salt marsh bulrush (S. robustus). Species composition varies primarily in response to existing soil salinities and hydrology. Tule are often associated with fresh standing water, while salt marsh bulrush favor saline, moist, or seasonally saturated soils. This community type is very limited in the IID and is usually associated with slightly higher topographic settings near the cattail community. However, these sites are often very wet, reflecting prolonged and highly saturated conditions. Tule stands are preferred habitat for the Yuma clapper rail. Bulrush stands were observed in San Felipe Wash, the Finney-Ramer Wildlife Area, and in seeps along the East Highline Canal. The extensive bulrush stands were associated with freshwater environments.

G.2.3 WILLOW COMMUNITY

The willow community is another very restricted wetland type in the IID. Only a few stands of this type were identified in the survey area. Frequently, willow was mixed with other shrub species such as salt cedar. The dominant species is Godding willow (Salix gooddingii). Willow was most commonly observed as small groups of individuals associated with saturated, upland areas with very low soil salinities. It was a common component of the large seepage areas south of the All-American Canal, but because its occurrence was so dispersed, it was impossible to delineate as discrete mapping units. Common plant associates were common reed, Fremont cottonwood (Populus fremontii), and salt cedar. Cottonwood occupies much of the same situation as willow. There were no significant cottonwood stands observed in the survey area, although cottonwood-willow complexes were historically important native riparian types in southern California.

G.2.4 RUSH COMMUNITY

The rush community is another very restricted wetland type in the IID. It constitutes less than 1% of all wetlands. This type is characterized by homogeneous stands of needlerush (Juncus roemerianus) on saturated alkaline or saline soils. One small area along the East Highline Canal was the only mapable unit identified. Needlerush is mixed with other community types along the East Highline Canal, notably saltgrass (Distichlis spicata), salt cedar, and arrowweed. All these types are also tolerant of saline/alkaline soils. Needlerush is interspersed among the common communities of the seeps south of the All-American Canal, but its occurrence is so dispersed that it is impractical to delineate as a separate type.

G.2.5 SALTGRASS COMMUNITY

The saltgrass community is an indicator of seasonally or permanently saturated soils with moderately high salt or alkali concentrations. It constitutes another relatively minor wetland community type of the IID. It occupies about 0.5% of the total wetland acres. It occurs predominantly along low depressions of the East Highline Canal and in flood plain oxbows of the New River. Examples of this type are usually small and very homogeneous in species composition. The dominant species is saltgrass, which is one of the few grasses that can tolerate the harsh, moderate to highly saline soil conditions. As soil conditions become more saline but maintain about the same moisture conditions, iodine bush and seepweed become prevalent. As soil conditions become less saturated and saline, salt cedar and various species of salt bush (Atriplex spp.) become prevalent. Consequently, the saltgrass community commonly intergrades with several other wetland types, the type depending on local soil moisture and salinity conditions.

G.2.6 IODINE BUSH-SEEPWEED COMMUNITY

The iodine bush-seepweed community occurs on sites with high soil salinities and prolonged periods of soil saturation. As with most communities associated with harsh saline growing conditions, species composition dominants are iodine bush (Allenrolfea occidentalis) and seepweed (Snaeda torreyana var. ramossissima). Other salt-tolerant species such as salt grass, salt cedar, arrowweed, and several species of salt bush may occur as minor components. This community typically possesses very little groundcover, and the individual plants are widely scattered.

Consequently, it offers very few wildlife benefits. This community constitutes about 2% of the wetland resource and is frequently found is flood plains of the New and Alamo Rivers.

G.2.7 COMMON REED COMMUNITY

The common reed community is widely distributed throughout the IID. It constitutes about 5.9% of all wetland resources inventoried. This type usually occurs as small to moderate-sized stands immediately adjacent to rivers, canals, and larger capacity irrigation ditches. Most stands tend to be homogeneous, being composed exclusively of common reed. However, common reed will occasionally intermix with cattail, salt cedar, and arrowweed. Common reed communities require moderately saturated soil condition and can tolerate both nonsaline and low salinity conditions. Common reed usually appears on slightly higher topographic settings than cattail and bulrush. It can tolerate moderate flooding. This community often provides hiding and roosting habitat for a wide array of wading birds and songbirds.

G.2.8 GIANT REED COMMUNITY

The giant reed community has ecological requirements similar to those of the common reed, except that the giant reed occupies sites with drier and more saline soils than the common reed. This community type is relatively minor in the survey area, comprising only about 0.7% of all wetlands. The community dominant is the giant reed (<u>Arundo donax</u>), which forms homogeneous stands in some cases but was most frequently observed as a minor component of common reed, salt cedar, or salt cedar mesquite types. Thus, this species is more widely distributed than the total mapped acres would suggest. Giant reed was most frequently observed in the seepage wetlands along the All-American and East Highland Canals and in the flood plains of the Alamo and New Rivers.

G.2.9 SALT CEDAR COMMUNITY

The salt cedar community and its complexes with arrowweed are the most abundant and widespread riparian types of the inventory area. It occupies and dominates about 33.6% of all wetlands. The dominant species is salt cedar (<u>Tamarix chinensis</u>), but other tamarisk species (<u>T. aphylla</u> and <u>T. ramossissima</u>) are often common locally. This community is the most water and salt tolerant of the riparian woodland types. It is a very aggressive and stable riparian community type, once established. Salt cedar is displacing the cottonwood-willow riparian community throughout the desert southwest, especially where saline soils inhibit growth of cottonwood and willow. Its aggressiveness is linked to current hydrologic and land use changes occurring along major stream drainages. Salt cedar communities occupy an intermediate position among wetland communities along the continuum from wet to moist conditions. Salt cedar occupies extensive areas along all drainages and canals within the IID, as well as at all major agricultural sumps and at other poorly drained alkaline places.

This community intergrades or borders with common reed, saltbush, mesquite, arrowweed, giant reed, willow, seepwillow, rush, and saltgrass. Its species composition and relative abundance of species vary dramatically by site. However, all cases include salt cedar. Salt cedar is very fire-tolerant, much to the disadvantage of native riparian species, because the flammable salt cedar carries fires that displace other species.

G.2.10 SALT CEDAR-ARROWWEED COMMUNITY

The salt cedar-arrowweed community is the second most abundant type within the survey area. It occupies about 24% of the total wetland/riparian acres. The community is characterized by the dominance of salt cedar and arrowweed. The relative composition between salt cedar and arrowweed will vary widely among sites, but all sites of this type have both species occupying at least 25% of the canopy cover. Typically, salt cedar will be the dominant canopy species and arrowweed will comprise the understory. There is usually a very poorly developed ground cover in these stands. Site conditions and other species associations are very similar to the salt cedar community, except that arrowweed tends to favor somewhat less saturated soil conditions. This type is most commonly encountered along the All-American Canal and the New River flood plain.

G.2.11 SALT CEDAR-MESQUITE COMMUNITY

The primary occurrences of the salt cedar-mesquite riparian community are along the East Highline Canal (especially the northern reaches) and at the All-American Canal just a few miles east of the confluence with the East Highline Canal. This type of community constitutes about 9.5% of all wetland/riparian acres. The salt cedar-mesquite riparian type represents the most drought-tolerant type present within the inventory area. It usually occupies the most upland reaches of the flood plain where soil saturation is the lowest. This community is able to extract sufficient moisture from the underlying water table through deep root systems of the dominant species. It is not apparently dependent on any type of periodic flooding or extensive intervals of soil saturation, but it attains its most robust conditions where soil moistures are relatively high. Mesquite can reach groundwater to depths of 45 ft. The salt cedar-mesquite community frequently boarders the true upland desert communities such as creosote bush or acacia. This community is dominated by salt cedar, honey mesquite (*Prosopis glandulosa* var. *torreyana*), and screwbean mequite (*P. pubescens*). This riparian type is an important habitat for many species of wildlife, especially songbirds.

G.2.12 ARROWWEED COMMUNITY

The arrowweed community constitutes about 15% of all wetland and riparian acres in the inventory area, making it the third most abundant type. As noted previously, it is extensively associated with salt cedar and forms large complexes throughout the IID. However, this community type represents those situations were arrowweed forms stands composed of 80% or more of this species. Arrowweed is shallow-rooted and, therefore, requires relatively moist soils to develop and sustain itself. Arrowweed is found along all perennial and intermittent drainages. It occurs in all other wetland types where salt cedar also occurs. Typical arrowweed stands have dense canopies that exclude development of much ground vegetation. These dense stands provide good hiding cover for many species of birds and small mammals.

G.2.13 SALTBUSH COMMUNITY

The saltbush community occupies about 457 acres or 5% of the inventory area. Several species of saltbush (commonly referred to as wingscale) are present, but allscale (Atriplex polycarpa) is the most common dominant. Quailbrush (A. lentiformis) and wingscale (A. canescens) are additional related species that occur in this community type. The saltbush community is usually associated with saturated and saline soils. This type is less salt-tolerant than the iodine bush-seepweed community previously discussed. However, the saltbush-type looks physically quite similar. Groundcover may be sparse with plants widely spaced. Typical sites are moist and saline with a shallow water table, usually occurring in the wide flood plains of the New and Alamo Rivers. Associated species include paleleaf goldenweed, mesquite, and salt cedar. With increased salinity, this type intergrades with the iodine bush-seepweed community.

G.2.14 SEEPWILLOW COMMUNITY

The seepwillow community is a minor wetland type that occupies about 0.1% of all wetland/riparian acres in the inventory area. It is a riparian shrub type that occurs in more upland settings of river or stream flood plains, although it can tolerate seasonally saturated soils. It was noted along Salt Creek Slough and the Alamo River. The dominant species is seepwillow (Baccharis glutinosa), which forms dense stands with 90% to 100% canopy cover. Seepwillow also occurs as a secondary species in the salt cedar, common reed, and salt cedar-arrowweed communities.

G.2.15 MISCELLANEOUS WETLAND RESOURCES

Aerial photography was limited to the six areas described in the scope (subsection G.1) because it included all significant wetland/riparian habitat, including Yuma clapper rail habitat, identified by the FWS (Bransfield, 1985). However, wetlands/riparian habitat also occur in other areas of the IID such as in irrigation drains. One such freshwater wetland community was noted during the inventory but was not mapped or tabulated because of incomplete aerial photo coverage. This type occurred as wetland corridors in the bottoms of the larger tailwater drains and ditches. The linear wetland occurs as a 5-ft to 10-ft-wide corridor along either side of unlined drainage ditches. Species composition was variable. The most common plants observed during the inventory were cattail, rabbit's foot grass, smartweed, curly dock, and several kinds of rushes, sedges, and spikerushes. Not every return drain contained this wetland type, but many did. Based on field observations and sampling of existing aerial photography, it appears that the emergent marshes that have developed in the ditches may represent a significant wetland resource in the IID. This is true not only from an acreage perspective but also from wildlife use and habitat standpoints. Based on an average continuous wetland corridor width ranging from 10 ft to 15 ft, approximately 1.2 to 1.8 acres of emergent wetlands would be present per linear mile of drainage ditch. There are approximately 1,305 miles of unlined lateral canals and drains presently in the IID. Assuming that 50% to 75% of these laterals and drains support wetlands, there could be from 783 acres (50% wetlands at 1.2 acres/mile) to 1,762 acres (75% wetlands at 1.8 acres/mile) of associated wetlands.

These corridor wetlands were noted to support a wide array and abundance of waterfowl, wading birds, shorebirds, and other songbirds during the field inspections. The large proportion of vegetation-water interface, shallow water depths, and easy access to food or prey items makes these wetlands very attractive to many wetland-associated bird species. The abundance and diversity of species observed reflected these conditions.

G.3 DRAINAGE WETLAND CHARACTERISTICS

The following subsections describe the overall wetland resources by drainage area. The areas are discussed in order of decreasing amount of wetland and riparian resource.

G.3.1 NEW RIVER

The New River flood plain and associated tributaries and nearby water bodies support approximately 3,315 acres of wetland and riparian resources. This total represents about 36% of all such resources inventoried in the IID. The most common and widely distributed wetland/riparian type was salt cedar, followed by arrowweed and the salt cedar-arrowweed complex. These three types constitute about 86% of the wetlands in the drainage area. The New River flood plain is relatively wide with many flood plain sloughs, oxbows, ponds, and other standing water areas, especially in the reaches south of Brawley. The wide flood plain and complexes of standing water and wetland community types make the southern New River attractive to many waterfowl and wading birds. Numerous feeding ducks and an egret roosting location were observed. Wetland conditions and wildlife habitat value degrade rapidly as one proceeds northward toward the Salton Sea. Very few acres of wetland and riparian areas exist at the Salton Sea confluence. Several locations supporting cattail and common reed communities suitable for potential Yuma clapper rail use were noted along the river. The most notable locations were near

Sunbeam Lake, south of Brawley, and the vicinity of the Greeson Wash confluence.

G.3.2 ALAMO RIVER

The Alamo River flood plain and associated tributaries support approximately 2,289 acres of wetland and riparian resources. This total represents about 25% of the total wetlands. In order of decreasing abundance, the three most common wetland community types are salt cedar, arrowweed-salt cedar complex, and saltbush. These three types constitute about 79% of the wetlands associated with this drainage. The Alamo River flood plain is relatively narrow and usually heavily vegetated with salt cedar and one or more of its secondary associates. The riparian zone is usually quite narrow because of the small width of the flood plain. Two major wetland management areas occur along the river, the Salton Sea National Wildlife Refuge (NWR) and the Finney-Ramer unit of the Imperial Wildlife Area. Substantial earthworking activities were being conducted in both areas. Large tracts of salt cedar and/or mesquite-salt cedar communities were being graded or flooded. Several locations supporting cattail and common reed communities suitable for potential Yuma clapper rail use were noted along the Alamo River. The most notable of such sites were near or in the Finney-Ramer units and in the Salton Sea NWR. With the exception of these two areas, general wildlife use of the drainage was limited to only a few sporadic observations of waterfowl and wading birds.

G.3.3 ALL-AMERICAN CANAL

The seepage wetlands and canal riparian communities associated with the surveyed reach of the All-American Canal comprise approximately 1,681 acres. In order of decreasing abundance, the three most common wetland communities are salt cedar-arrowweed, arrowweed, and salt cedar-mesquite, which collectively constitute about 86% of the wetlands associated with this reach. Although common reed occupies both banks of the All-American Canal for most of its length, the substantial wetland communities are associated with ground water seepage through the unlined canal. Extensive wetlands occur both north and south of the canal. Areas of standing water with associated cattail, common reed, and several other emergent marsh species occur to the south. These sites are known to support Yuma clapper rail (Bransfield, 1985). The largest acreage of cattails occurs in these marshes. Extensive salt cedar, mesquite, and arrowweed stands occur north of the canal. These areas have not substantially changed in appearance since the 1979 wetlands field study was conducted (ES, 1980).

G.3.4 EAST HIGHLINE CANAL

The East Highline Canal and associated seepage areas support approximately 1,433 acres of wetland and riparian resources. This total represents about 16% of all wetlands inventoried in the IID. In order of decreasing abundance, the three most common wetland types are salt cedar-mesquite, arrowweed, and arrowweed-salt cedar complex, which collectively constitute about 78% of the wetlands associated with this canal. Several large wetland tracts lie east of the canal about midway along its length. These tracts contain a complex mixture of salt cedar, cattail, common reed, arrowweed, and saltbush types. Yuma clapper rail habitat may exist at these locations. Wetland units elsewhere along the canal are linear, very narrow, and usually small. Numerous irrigation drainage canals possessed the freshwater marsh vegetation discussed previously. Not much of the wetland resources associated with this canal have changed substantially since they were inspected in 1979 (ES, 1980). Wetland resources generally decrease in abundance and size going northward. Standing water areas are present, but they are usually small and widely scattered.

G.3.5 SALT CREEK SLOUGH

Salt Creek Slough supports approximately 420 acres of wetland and riparian resources, which represents about 5% of the total wetlands inventoried in the IID. The three most common wetland types, listed in order of decreasing abundance, are saltbush, common reed, and arrowweed. These three types constitute about 73% of the total wetlands associated with this drainage. Large stands of common reed are frequently present. Salt cedar is relatively uncommon in this drainage. The drainage is narrow throughout much of its length, making the corridor long and narrow. A few relatively large cattail and common reed stands occur in the drainage, which offers potential Yuma clapper rail habitat. Only one or two major standing water areas are present, and the stream is often obscured by dense riparian vegetation. Basic vegetation appearance remains very similar throughout.

G.3.6 SAN FELIPE WASH

The surveyed reach of San Felipe Wash supports approximately 72 acres of wetland resource, which comprises less than 1% of all wetlands inventoried in the IID. The three most common wetland types, listed in order of decreasing abundance, are salt cedar, cattail, and arrowweed. Collectively, these three types comprise about 72% of the total wetland acres present at the site. Common reed is about as abundant as arrowweed, and it increases the total composition to about 86% when added to the total. The wetland composition of the wash changes dramatically in the short reach examined. At the upper end, it consists primarily of moist soils with dense salt cedar, common reed, and arrowweed. Through the middle reach, cattail, common reed, and bulrush become prevalent and open standing water appears. The lower reach is predominantly open standing water, bordered by cattail and common reed. San Felipe Wash was one of the better wildlife habitat areas noted in the IID inventory area. Much of the wetland areas appeared capable of providing Yuma clapper rail habitat.